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PREPARATION FOR A MEDICAL CAREER

Presidential Address

CASPER F. HEGNER, M.D.
DENVER

EACH period of history of the human race had its characteristic medical status.

In the beginning the causes of illness and the means of their alleviation were based on the supernatural. The healers were mystics or conjurers.

The next period (400 to 500 B. C.) witnessed the development of philosophy and the dawn of scientific observation in the concept of disease. The devotees of the healing art made a study of man and his reaction to his environment. It was appreciated that these were important factors in the development and well-being of man.

Then followed a period during which the plan of separation was developed. A healer or a physician became interested in or treated a single disorder or a disease of a single organ or system. The human organism as a whole was overlooked in concentrating on a relatively small part. This is like the system of specialties today.

With the advent of bacteriology, science began to broaden and dominate the field of medicine. By establishing bacteria as the exciting or specific cause of disease many proved factors influencing the invasion and course of the disease as well as its epidemiology were overshadowed.

This was followed by the present laboratory era of medicine, in which laboratory facilities and technicians' reports bear the frontal attack and continue as major factors of the campaign in the study, diagnosis and treatment of disease. The host of the disease receives consideration secondary to the more spectacular local phenomena.

War has influenced and will continue to influence medicine in all its aspects, not the least being the tremendous if not excessive emphasis on specialization. Personal qualifications, premedical studies, medical, clinical and graduate teaching, intern, resident, hospital staff and group practice are destined to be vastly different. Private practice as of the past fifty years, during the period of greatest advance in medicine, will become legendary.

Read at the fourth annual meeting of the Central Surgical Association, Chicago, Feb. 21, 1947.

The direction, speed and extent of these changes will depend largely on you men who have recently graduated. You are on the threshold of the greatest epoch in history. The present demands alert, young, well prepared, courageous men to mold the minds of students, to determine the teaching methods and the future trend of medicine.

You must be conversant with medical history and the traditions of the past. You must qualify as research workers, teachers, clinicians or practitioners. All must be sensitive to and active in the rising tide of politicoeconomic plans that may make or mar your individual and collective efforts for the best interests, welfare and service of mankind.

A neglected but increasingly important duty is to encourage students who are personally and scholastically qualified, who are interested in and wish to study medicine. Much can be done in guiding and advising in their preparation.

Selecting a vocation is one of the most important acts of a lifetime. Always perplexing, it has become more so with increasing complexities of modern living. Considering how uninformed one is when so momentous a decision is usually made it is remarkable so many make a fortunate choice.

Knowing what you want, and to want it with all your heart, is more than halfway along the arduous road to attaining your objective.

Knowing where and how best to prepare for one's ideal presents problems. In solving these one must depend on others with experience for guidance. The earlier one receives proper direction, the sooner and more thoroughly can one prepare for one's life work. The inception of this understanding should be in the home.

The modern American home has lost much of the character-building influence which it formerly enjoyed. The radio with its expert commentators make one indifferent in one's reading and thinking about the news and what makes it. Its excellent artists on special programs make one impatient with amateurs. Motion pictures are setting a comparatively low standard in taste and amusement. They divert one from evenings at home, dull one's interest in current events, friends, family and conversation.

Recorded music by master artists stimulates one's taste for the best, but discourages lesser professional musicians and many others.

This penchant for outside diversions is lessening the desire for self improvement and companionship and is weakening the home influence which has been the bulwark of the American way of life.

It is in the home that character is built, that influences for good are strongest and the urge to accomplish and progress receives its earliest impulse. It takes time, personal energy, interest and sacrifice to build, strengthen and make an attractive home life and to foster the interests of the children. For them the home is paramount.

Every parent should have at heart and in mind the best interest and future welfare of all his children. He can sensitize them with a desire to learn and encourage them to think and to have consideration for others. He can sow the seeds of their future character.

All too early this important phase of child guidance and training is shifted largely, if not entirely, to the public schools. There the task is for the many. The unusual, the apt children are not carried forward. Facilities to advance them are not provided. The overcrowded rooms and the multiplicity of subjects confuse the children and hamper and overwork the teachers. Whatever their inclination they have no time to give to unusual pupils. A qualitative principle from the point of view of the teacher and the taught is more important than the quantitative plan which dominates the present educational program. The objective should be how thoroughly fundamental subjects can be instilled into the minds of pupils of the same average age and mental capacity with varying grades of receptivity.

High schools could develop a plan whereby pupils with greater aptitude and scholastic ability are grouped in classes and courses best suited to preparation for advanced education.

Education must be available for all from the lowest school grades up through the institutions of higher learning. More consideration should be given to the fact that all are not equally receptive of instruction, all do not develop with equal rapidity or in equal degree.

A system graded solely to the mental capacity of the average cannot give adequate instruction to the more receptive pupil. He, for want of the stimulus of competition, develops a sense of superiority and becomes indifferent, mentally lazy and a time waster. Conversely such a course is geared too high for the less than average pupil who needs more time and requires more instruction and attention than can be given him. He becomes acutely aware of his inability to keep up with his class, becomes discouraged, acquires an inferiority complex and falls farther behind.

The system of teaching with courses graded solely for the average pupil is wofully wasteful of time, effort, material and minds. It lowers the standard for all. It neglects the group from which the leaders of tomorrow are recruited.

A grouping in classes of pupils according to aptitude, scholastic ability and receptivity and arranging courses and type of instruction best fitted to the capacity of each group is efficient, economical, practical and progressive pedagogy.

This is vital for the candidates for professional, scientific and advanced education. By the time that students are ready for college there must be some indications that all are not equally capable or interested. Arranging courses and classes to coincide with the receptivity and mental capacity of the students is imperative in college.

The instructor by virtue of experience and intimate contact with students should be in a position to group students and to advise and outline courses best suited in preparation for the vocation of their choice.

Thus may one's abilities be estimated, aptitudes discovered, interest aroused and efforts encouraged. A future suited to one's capabilities, talent and desire can then be planned more intelligently.

The virtue of study is to discipline the mind to think and to reason. In direct ratio to one's ability to think will be one's status among one's fellow men. Thinking opens unexplored realms of science and human relations and blazes trails of progress that others may follow. Comparatively few medical freshmen known how to study or have ever been taught to think.

The ultimate in education is to develop the minds of youth to the end that they may attain the greatest degree of personal happiness and efficiency in rendering the highest grade of service to society; i. e. making the world a better place in which to live.

A university to be effective supervises and trains students for the responsibilities of civic, business and professional life.

Selection of students best suited to and qualified for advanced education should be an important function of college faculties. Personal fitness, character, scholastic aptitude, ability and manners are important qualifications. Worthy students should be financed by grants, scholarships, fellowships and residencies.

There are no reliable short cuts or hurdles to a thoroughly grounded well balanced education. It takes conscientious, continuing and concentrated study. Recognizing one's limitations and taking timely appropriate measures to overcome them are duties never fully discharged.

It is unusual in choosing medicine as a career to appreciate what such a choice involves: the expense, years of preparation, long period of unremunerative work and the lean years of getting established in practice. All this the prospective medical student should know and be able to cope with cheerfully and patiently.

I have always been interested in the reasons which prompted students to select a career in medicine. Of the many interesting answers to this question only a few stated that it was a desire to be of service to humanity.

The welfare of and service to humanity are the true motives for choosing a medical career. Service is and always will be the abiding passion of the true physician.

For the highest type of service, he must love his profession and mankind above all. He must have physical, nervous and psychic stamina, possess a sense of humor, good manners, pleasing address and be honest, honorable, unselfish, patient, tactful, charitable and understanding. Besides these personal qualifications he must be endowed with a receptive mind and a retentive memory, a scientific and scholastic aptitude spawned

in the home, developed in school and activated by a broad academic course. Only on such a foundation can an eminentally successful medical career be developed.

There is no limit to improving one's self. Perfection is unattainable, but one must keep on trying. The pursuit of perfection in the service of mankind is the noblest ideal. It is the activator of laudable human endeavor and the irrepressible stimulus to ambition. The true physician is happy in this quest.

Nothing matures like time. Maturity develops experience and sympathetic understanding of human, spiritual, scientific and material values, the foundation of good judgment.

Routine technic and operative procedures are comparatively easily taught. Judgment and intuition, doing the right thing at the right time in the right way, cannot be taught so easily. It must be acquired by experience, profiting as much, if not more, from one's failures as from one's success.

To alleviate the miseries of mankind one must have a profound respect for the wisdom of the past. One must know the natural history and course of disease. This develops better understanding of the present, gives greater promise of the future control of disease.

Masters of the past, with little to guide them but keen observation and logical deduction, pioneered many leads which on investigation with the scientific equipment of a later day became established facts.

It is given to but few to discover a new procedure, a better technic or more potent remedy, the real cause of, or a specific cure for, disease.

To learn the causes of illness, to know the factors for success and the reasons for failures of treatment is the ambition of all. This is the province of the research worker in the laboratories and the clinical investigator in our teaching hospitals.

Uncontrolled enthusiasm for the new and untried leads to unwarranted hopes and subsequent disappointment.

All may put to practical test that which has given promise. Record your experience, let neither enthusiasm of success nor discouragement of failure deter you from making a contribution to medical experience. Of such is true progress made.

Many of you are now, and some will continue to be affiliated with teaching institutions. Teaching is a serious responsibility, a stimulating and valuable experience. The most gratifying being to know you have been even in a small way responsible for the success of your students.

Others fired by the spirit of service will go far afield from medical centers and ready to hand laboratory aids. The larger duty of the members of the medical profession is to see that when and wherever services are required, there will be competent medical and surgical attendants. Being well prepared and thoroughly trained one will give excellent service

and acquire a rich experience. From the far flung frontiers of medicine one can make important observations and valuable contributions scarcely second to the studies of classic, cloistered, scientific laboratory and clinical research workers.

The true science and study of mankind is man. The reaction of the human organism as a whole is no less important than is its local reaction to disease.

Jean Nicolas Corvisart (1755 to 1821), the first cardiologist and a great teacher, brusquely asked a student who came into his clinic what he came for. "To study, sir," replied the student. "Good," replied Corvisart and, pointing to the assembled patients, said, "there are your books, but they are not so easy to read as a printed book." [1]

Comparative animal experiments and research are most valuable scientific procedures. These probe paths for progress in medicine. They can never fully replace clinical observation and research, which carry the seed and product of science to benefit the ill patient.

The art of medicine, clinical, comparative and scientific research are all important. They do not conflict but are correlated one with another. Progress can neither be made nor be maintained if one is divorced from another.

It takes different temperaments and qualifications to become a scientific investigator or a clinician. A truly scientific research worker is one for whom the quest of perfection, the solution of problems and the establishing of cold facts and irrefutable principles transcend all. A clinician searching for infallibility applies these facts and principles in the critical study and treatment of his patients and their disease.

A good clinician or practitioner must be patient, observant, tactful, versatile, charitable, understanding, honest, honorable and tenacious of the right. A surgeon in addition must have the spirit of a discoverer, the courage of the righteous, the heart of a champion and the judgment of a sage. He must be resourceful, considerate but still decisive, firm yet gentle and capable of executing all his manipulations with consummate skill and dexterity.

To acquire these necessary qualifications one must have contact with many patients of every variety. One must learn by observation and by the teachings of his superiors in hospital service. A rotating internship of not less than a year and a half in a good teaching hospital gives a wide experience with many patients in all phases of practice under supervision of a number of different instructors. This should be followed by a residency of not less than two years in a service of one's choice, in a teaching hospital preferably in an entirely different section of the country. This contact with new types of persons, new teachers, new

1. Hinsdale, G.: Our Medical Debt to France, Ann. M. Hist. 4:154-166 (March) 1942.

ideas and new environment has a decidedly broadening influence. The surgical resident should seek frequent advice and counsel of his fellow residents and staff members, especially in difficult cases, cases with confusing complications or in any circumstance that interrupts a smooth progress. A desirable habit of seeking advice thus formed and carried into private practice cannot but benefit him and may help the patient.

From a broad foundation in general medicine and the many contacts with various specialties and specialists during one's hospital training, one may, if so minded, select a specialty for which one is best qualified and which seems most attractive and interesting. The additional years of intensive training required for qualifying as a specialist has more than justified the prolongation of the training period.

The better basic training in general medicine, the more satisfying will be one's experience and the more acceptable one's service in any specialty. Whichever specialty one chooses, one never should lose the inspiriting touch of general medicine. One should always keep the goal in mind, from which there should be no diversion.

The young surgeon should establish a reputation for dependability. He should cultivate the acquaintance of his colleagues. The better they know one another the better each will be, and the greater will be the respect for the medical profession. He should be a consistent attendant at medical society meetings, where he may learn or impart something of value to others.

In addition to your major interest in practice, become alert and active in the changing conditions under which that practice will be carried on. These changes, unless guided by you, may seriously or radically restrict the freedom under which American medicine has advanced beyond that of any other country at any time in history. No individual or group of individuals has more knowledge of the ills of humanity or knows better how to prevent or treat them than you. Keep abreast of these trends lest you be deprived of your vested right to serve suffering humanity and become subservient to a blighting political program which spells doom to the traditions of our proud past and our present well earned worldwide reputation.

Your society will secure and maintain a preeminent position if each one of you does his part and unstintingly supports his officers. Your society's main purpose is to become a forum for the free interchange of experiences and ideas that all may profit; be encouraged and stimulated to advance the knowledge and science of surgery.

With honesty and honor in your relations one to the other, with good preparation for your duties and earnest application, you cannot fail to reach heights beyond your fondest expectations.

227 Sixteenth Street.

GASTRIC ULCER FOLLOWING RADIATION

COLONEL FRANK E. HAMILTON
MEDICAL CORPS, UNITED STATES ARMY

ULTRAHIGH voltage roentgen radiation is frequently used in the management of certain malignant growths. As additional tumor centers are constructed, the use of 1,000,000 volt, and even higher, radiation therapy will increase. Excellent results are being obtained after massive high voltage roentgen irradiation of radiosensitive malignant growths. However, at Walter Reed General Hospital it has been noted that after application of 1,000,000 volt radiation to retroperitoneal nodes in the region of the normal stomach an unusual secondary lesion may occur. Occasionally atypical gastric ulcer develops near the pylorus. The chief symptom is hemorrhage. Perforation has occurred. This condition has been reported elsewhere as a terminal phase of the malignant process. It is, however, usually amenable to surgical treatment.

Similar secondary effects are not new. Gastric ulcer was produced experimentally by Engelstad [1] after heavy irradiation of the normal stomach of rabbits. Hueper, de Carvajal-Forero [2] and others produced radiation ulcers in the normal dog stomach. Curling, Lee, Leonard, Weiskotten and Bardeen [3] have all reported ulcers of the stomach and duodenum following cutaneous thermal burns.

PRESENT STUDY

At Walter Reed General Hospital 256 radiosensitive malignant tumors of the testis were treated with 1,000,000 volt roentgen radiation.[4] The present procedure is the application of a test dose of radiation to

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From the Walter Reed General Hospital, Washington, D. C.

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn., Dec. 6, 1946.

1. Engelstad, R. B.: The Effect of Roentgen Rays on the Stomach in Rabbits, Am. J. Roentgenol. **40**:243-263 (Aug.) 1938.

2. Hueper, W. C., and de Carvajal-Forero, J.: The Effects of Repeated Irradiations of the Gastric Region with Small Doses of Roentgen Rays upon the Stomach and Blood of Dogs, Am. J. Roentgenol. **52**:529-534 (Nov.) 1944.

3. Curling; Lee, W. E.; Leonard; Weiskotten, H. G., and Bardeen, C. R., cited by Bancroft, F. W.: Cutaneous Burns, in Christopher, F.: A Textbook of Surgery, ed. 3, Philadelphia, W. B. Saunders Company, 1942, pp. 60-68.

4. Amory, H. I.; Friedman, M.; Greenfield, M. M., and Brick, I. B.: Personal communications to the author.

determine the sensitivity of the tumor, followed by radical orchiectomy. Later the retroperitoneal glands are given massive prophylactic irradiation. The proportion of clinical cures of the malignant growth is high —80 per cent for seminoma and 50 per cent for teratocarcinoma.

It was noted that when the radiation dose to the region of the normal stomach exceeded 5,000 r atypical symptoms of epigastric distress developed in about half the patients. The condition of most of these patients improved under treatment; in 35 of them a large, single gastric ulcer developed, as proved fluoroscopically.

The symptoms exhibited by these patients were atypical. The only constant symptom was epigastric distress, of varying degrees, first noted two to three months after completion of the roentgen irradiation. Some of the patients exhibited the complex of pain relieved by food usually associated with gastric ulcer. In some there developed rather severe epigastric pain with no relation to food. In some the first symptom was gastric hemorrhage, occasionally severe. The degree of gastric acidity was likewise atypical. In some patients the acidity was somewhat increased; in the majority it was normal, or even subnormal.

After medical treatment, most of the patients were clinically cured of the gastric ulcer and were discharged. Six required operation.

The first of the patients with radiation ulcer to be operated on had a proved gastric ulcer with minimal epigastric distress. Suddenly uncontrollable gastric hemorrhage developed. Col. Ralph Bowers, then chief of surgery, decided to attempt a palliative operation. He was unable to locate the exact position of the ulcer, so did a subtotal gastric resection. The patient made a complete recovery. Colonel Bowers then operated in 3 similar cases, with postoperative death in 1 case, no improvement in another and clinical cure in the third. Since that time I have operated in 2 additional cases of radiation ulcer, with clinical cure in both.

The operative observations in these cases are somewhat bizarre. The irradiated areas of skin over the retroperitoneal nodes are brown and leathery in consistency. This factor, however, does not interfere with postoperative healing. Intra-abdominally, there are greatly increased fibrosis of the irradiated tissues and, usually, increased vascularity. The stomach and jejunum has a brown, burnt-out appearance. The dome of the diaphragm is usually high, and the stomach appears to be pulled into a higher position than normal. The mesentery of the colon and jejunum appears to be shortened. The omentum is usually a small, burned-out shred of tissue. In addition, the affected portions of the stomach and jejunum have a smoothed-out appearance and are leathery in consistency; no peristalsis is visible.

In all these cases in which operation was performed the ulcer was located on the posterior wall of the stomach near the pylorus. Two of

the ulcers perforated prior to operation, and in both instances the ulcer perforated onto the pancreas, where the posterior wall of the stomach was so fixed by fibrosis that the perforation was completely encapsulated.

There has been a recent exception to the previous cases. A discharged officer was known to have a radiation gastric ulcer, which was practically asymptomatic. While he was at a seashore resort, a perforation occurred without warning. He was retained in a local hospital for forty-eight hours without operation and was then flown to Walter Reed Hospital. On arrival he presented the picture of generalized peritonitis. He was placed under supportive therapy, but the peritonitis did not localize and he died.

Autopsy showed two perforated ulcers of the upper portion of the ileum. In all other respects the intra-abdominal picture was similar to that observed in the previous cases. This is the only case in which a demonstrable ulcer of the intestine developed.

The histories in the 2 cases in which I operated recently are typical of the group and are presented briefly.

REPORT OF TWO CASES

Case 1.—Radical orchiectomy (left testis) was done overseas on Sept. 7, 1945. The pathologic diagnosis was seminoma. The patient was transferred to Walter Reed General Hospital for radiation therapy. During the period from Oct. 27 to Dec. 20, 1945 he received 5,200 r to each of five portals: left suprapubic, umbilical, epigastric, lumbodorsal and lower dorsal. The total dose of high voltage radiation given in the region of the stomach totaled 10,400 r, administered through the epigastric and lower dorsal portals.

Mild radiation sickness developed. A roentgenographic series of the gastrointestinal tract, taken Jan. 30, 1946, was reported as showing "no organic lesions of the esophagus, stomach or duodenum."

On March 11, about three months after irradiation, he experienced moderate epigastric discomfort, which was relieved by food or milk. Fluoroscopic examination on March 13 was reported as follows: "The esophagus is normal; the mucous membrane of the stomach is greatly hypertrophied. The antrum shows spastic contraction. The duodenal cap fills normally. The picture suggests the effects of irradiation."

Epigastric distress increased. Fluoroscopic examination on April 20 was reported as follows: "The stomach shows narrowing and spasm toward the antrum. The pyloric sphincter remains patent, but flow through the sphincter is slow, with decreased peristalsis. Ulceration is suspected." Gastric analysis showed slight elevation of free hydrochloric acid.

On May 15 the patient was reported to have been vomiting small amounts of blood several times a day. Epigastric distress was less acute. Fluoroscopic examination on May 24 was reported as follows: "The rugae of the stomach are hypertrophied; the antral portion is narrow with distorted, smoothed-out rugae. Peristaltic waves are decreased over the antrum. The impression is that of radiation gastritis with ulceration."

There was further frequent bleeding, with vomiting of small amounts of blood; discomfort was less acute. On June 27 subtotal gastric resection was done,

with the Hoffmeister type of anastomosis (fig. 1). Recovery was uneventful. Repeated physical and fluoroscopic studies showed no evidence of metastasis.

CASE 2.—Radical orchiectomy (left testis) was done on Oct. 9, 1945; no metastasis was seen. The pathologic diagnosis was teratoma of the testis; mixed type.

Radiation therapy was administered from Nov. 27 to Jan. 5, 1946, 4,800 r being given to each of the five usual portals. A total dose of 9,600 r was delivered in the region of the stomach.

Moderate radiation sickness developed. By the end of March, three months after irradiation, the patient complained of occasional epigastric pain. The usual

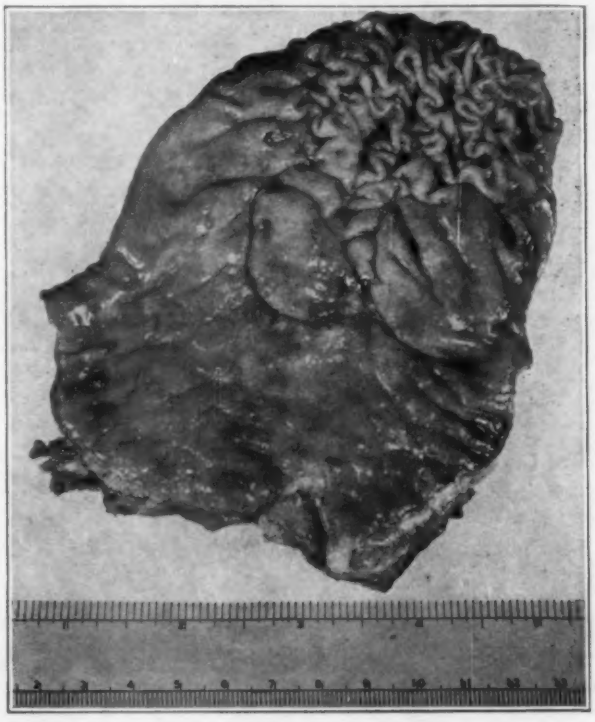

Fig. 1 (case 1).—Interior of the stomach, showing hypertrophied rugae in the cardiac portion and absence of rugae in the irradiated portion, with petechial mucosal hemorrhages and increasing edema near the pylorus. A portion of the ulcer appears at this point.

regimen for control of ulcer was instituted, with control of pain. By mid-April the patient occasionally vomited small amounts of blood and occasionally had tarry stools. At times there was considerable loss of blood through the intestinal tract. The hemorrhage was controlled by medical means, and for a time the patient was practically asymptomatic. On August 11 the ulcer perforated and at once encapsulated posterior to the stomach (fig. 2). An elective subtotal gastric resection was accomplished on August 15, with the Polya type of anastomosis; recovery was complete.

Gastric analysis during this period showed no free hydrochloric acid on March 2, slight increase in free acid on March 16 and a subnormal amount of free acid on August 14.

Fluoroscopic findings were reported as follows:

January 24: No evidence of organic lesion.

February 16: Hypertrophied rugae; central bulge on the greater curvature, simulating an ulcer crater.

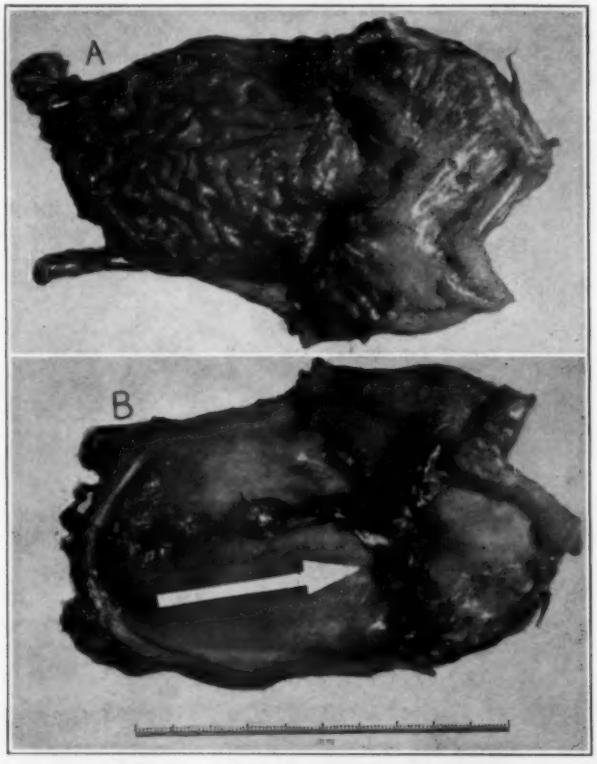

Fig. 2 (case 2).—*A*, interior of the stomach presenting the same characteristic appearance as that of the stomach in figure 1. The perforated ulcer is visible near the center of the specimen. *B*, stomach opened along the greater curvature. The arrow points to the perforation near the edematous pylorus.

March 30: Increased changes; no peristalsis in the antrum; definite evidence of ulcer.

April 29: Persistent barium-filled niche in the antrum near the greater curvature.

May 8: Antrum fixed, small and canalized; ulcer, 3 by 3 cm., on the greater curvature in the proximal half of the antrum; pylorus widely opened and fixed.

SUMMARY

Conclusions cannot be drawn from this small series of cases. However, certain observations seem constant. Unless these observations

are correlated, however, an increase in postradiation ulcer may be expected as additional tumor centers place in operation high voltage radiation therapy.

Two hundred and fifty-six patients received massive high voltage roentgen therapy for malignant growths of the testis at Walter Reed General Hospital. The apparent incidence of clinical cure of the malignant process was high—80 per cent for seminoma and 50 per cent for teratocarcinoma.

Certain unusual gastrointestinal complications occasionally arise during the course of treatment. One-half the patients treated experienced atypical epigastric distress from two to three months after irradiation. In 35 of these patients proved gastric ulcer developed in a previously normal stomach. However, if radiation therapy will apparently cure certain malignant growths of the testis, the subsequent development of gastrointestinal complications of moderate severity is relatively immaterial.

All the patients in whom radiation ulcer developed had a dose of radiation to the region of the stomach exceeding 5,000 r. Some patients, however, had radiation doses to the region of the stomach far exceeding 5,000 r with no ill effects. Thus, there appears to be an individual tumor sensitivity to radiation, as well as a personal sensitivity to the effects of radiation.

On the basis of these few cases, it is believed that the roentgenologist may predict the formation of an ulcer. Fluoroscopic examination has shown retardation and, finally, apparent absence of peristalsis in the antrum of the stomach in certain patients who have received heavy radiation to the retroperitoneal nodes. Later, in some of these patients a proved ulcer developed.

The symptoms were atypical of gastric ulcer. The effect of radiation on the gastrointestinal tract presents an unusual pathologic picture, but the lesion is by no means inoperable, as has been reported.

Further investigation is required to determine the exact causative factors in formation of the ulcer. There appears, however, to be an intimate relationship between the total radiation delivered to the region of the normal stomach and the development of this atypical gastric ulcer.

There have been 8 reported deaths with autopsy—6 in civilian hospitals and 2 in Walter Reed General Hospital. Subtotal gastric resection for radiation ulcer has been reported in 8 cases—2 in civilian hospitals, with postoperative death in both cases, and 6 in Walter Reed General Hospital, with postoperative death in 1 case, no improvement in 1 case and apparent clinical cure in 4 cases.

Walter Reed General Hospital, Washington 12, D. C.

ANATOMIC DISTRIBUTION OF THE VAGUS NERVES AT LOWER END OF THE ESOPHAGUS

Relation to Gastric Neurectomy for Ulcer

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SINCE Brodie's [1] first report, in 1814, on denervation of the stomach, an extensive and confusing literature has appeared. In many instances, in the literature reviewed on this subject the early and late effects of denervation have been confused and the results of section of the gastric nerves of man have been compared indiscriminately with those obtained on lower animals. Different workers have employed operations of different extent, and many investigators, too, have employed gastric neurectomy in the experimental production of peptic ulcer.[2] That there is no agreement on even the structure of these nerves, let alone their function, is reflected in recent reports, in one of which the author [3] concluded that the vagus nerve is composed of nothing but sympathetic fibers whereas in another [4] the authors denied the presence of any sympathetic fibers. In the present study we are concerned chiefly with clarification of the distribution of the gastric nerves immediately above and below the esophageal hiatus of the diaphragm.

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn., Dec. 6, 1946.

1. Brodie, B. C., cited by Hartzell.[10]

2. Beaver, M. G., and Mann, F. C.: The Production of Peptic Ulcer After Section of the Gastric Nerve, Ann. Surg. **94**:1116-1118 (Dec.) 1931.

3. Kiss, F.: The Relation Between Vagus and Sympathetic in the Vertebrates, J. Anat. **66**:153-156 (Oct.) 1931.

4. McSwiney, B. A., and Spurrell, W. R.: The Gastric Fibres of the Vagus Nerve, J. Physiol. **77**:447-458 (March 15) 1933.

At the meeting of the Central Surgical Association in February 1946, one of us (W. W.) discussed with Dr. Edwin Miller,[5] of Chicago, the problem of division of the vagus nerves in treatment of ulcers of the stomach and duodenum. Dr. Miller said that in dissection of approximately 30 vagus nerves he had been astonished to observe great variation of distribution of this nerve in the vicinity of the diaphragm. He expressed the belief that the patterns of distribution should be studied to determine whether all of the gastric branches of the vagus (or gastric) nerves could be removed successfully by transabdominal approach. He suggested that we at the Mayo Clinic might collaborate in such a study. The possibility of carrying out the study was discussed with Dr. J. W. Kernohan, of the Section on Pathologic Anatomy, and the work was begun with a survey of the literature, only a little of which will be reviewed here, and the dissection of the vagus nerves at autopsy in more than 100 cases.

Anatomic consideration of the nerves revealed a varied pattern in their course from the pulmonary plexus to the stomach and a remarkably constant course and distribution after the nerves reached the stomach. In dissection we concentrated on the region just above the stomach in order to determine whether the thoracic or the abdominal approach to the lower part of the esophagus was better.

ANATOMIC VARIATIONS OF THE GASTRIC NERVES

Our observations were made on 56 men, 44 women and 11 children. In general, the gastric nerves arose from the esophageal plexus at about the level of the bifurcation of the trachea. The right and left nerves coursed caudad and usually terminated on the stomach. Certain variations, however, led us to separate our cases into four groups.

According to Cunningham,[6] the vagus nerves as they pass from the esophageal plexus downward on the front and back of the esophagus through the opening in the diaphragm are termed "anterior" and "posterior" gastric nerves, respectively. In our investigations, the right nerve was not always posterior nor the left nerve always anterior to the esophagus as it passed through the esophageal hiatus, and we proposed the terms "right gastric nerve" and "left gastric nerve." Since any surgical procedure which would excise a section of a nerve is a neurectomy, the term "gastric neurectomy" is used for resection of the gastric nerves.

In 92 of our cases among adults the gastric nerves took origin from the esophageal plexus. In 85 of these cases this occurred on the anterior

5. Miller, E.: Personal communication to the authors.

6. Cunningham, D. J.: Text-Book of Anatomy, New York, Oxford University Press, 1943.

wall of the esophagus behind the bifurcation of the trachea and behind the main bronchi. In 7 cases it occurred on the lower part of the esophagus. As the gastric nerves coursed caudad, many intercommunicating branches were observed between the right and the left

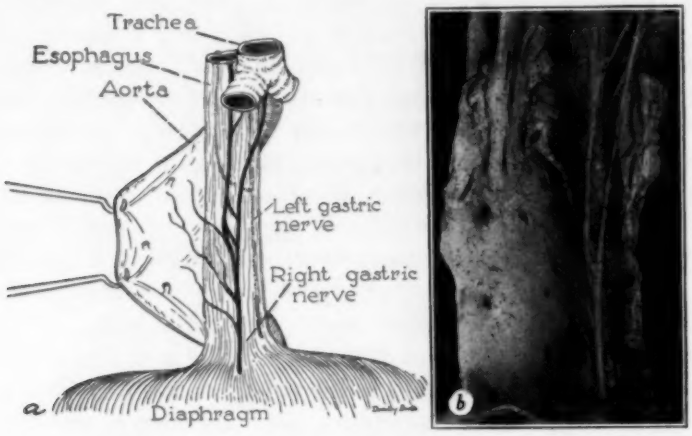

Fig. 1 *a* and *b*.—Formation of right gastric nerves from branches of the pulmonary plexus behind the trachea and the sympathetic branches posteriorly (group 1).

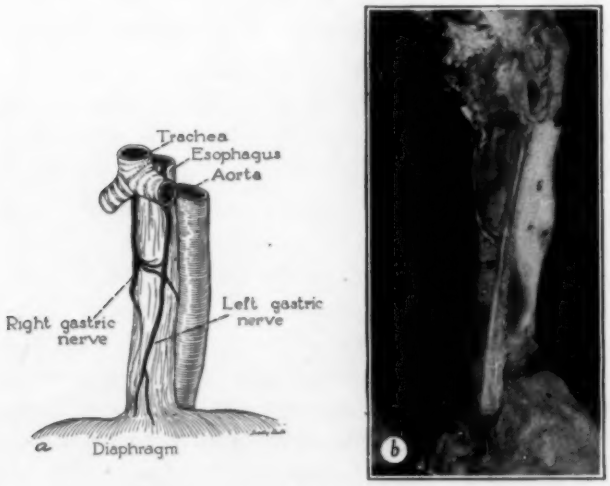

Fig. 2 *a* and *b*.—Formation of gastric nerves, demonstrating the absence of intercommunicating branches between the esophageal hiatus and a level 6 cm. above the diaphragm (group 2).

trunks. Additional fibers which joined the gastric nerves were small fibers that coursed anteriorly and inferiorly over the vertebral column and the aorta. Communicating branches were sometimes seen to enter the musculature of the esophagus and either lose their identity or

re-emerge onto the surface of the esophagus at some more caudad position. By the time the nerve trunks and branches had reached the esophageal hiatus two relatively large trunks were formed. These trunks passed through the esophageal hiatus, below which their course was remarkably constant.

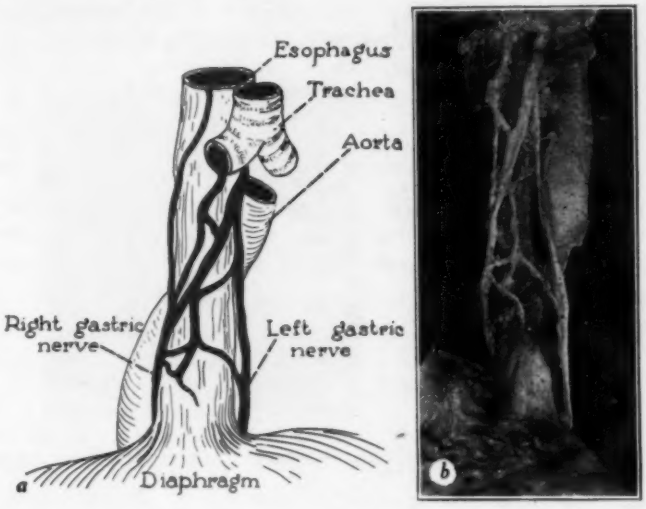

Fig. 3 *a* and *b*.—Formation of gastric nerves from the esophageal plexus (group 3).

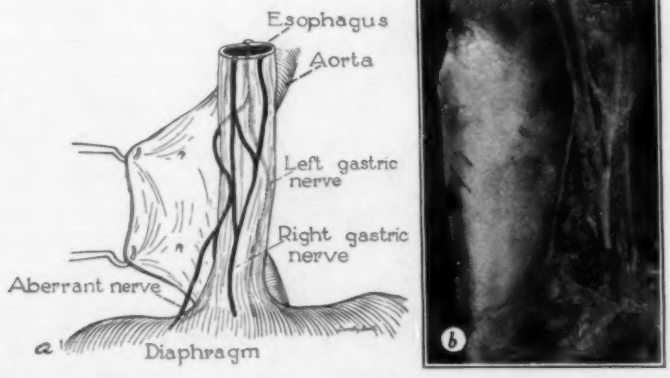

Fig. 4 *a* and *b*.—Right gastric nerve with aberrant nerve coursing laterally into the thorax (group 4).

The 92 cases constitute three of our four groups. In the first group all the branches between the gastric nerves and from more remote regions joined in common trunks, one on the right and one on the left side of the esophagus, somewhere between the esophageal hiatus and 6 cm. above the diaphragm (fig. 1 *a* and *b*). There were

64 such cases. In the second group long, discrete trunks were present without any addition to their fibers or any communicating branches for a distance of 6 cm. above the diaphragm (fig. 2 *a* and *b*). There were 21 such cases. In the third group the many intercommunicating branches between the main trunks of the gastric nerves formed a plexus over a major portion of the surface of the esophagus. The branches ultimately united and formed two main trunks at the esophageal

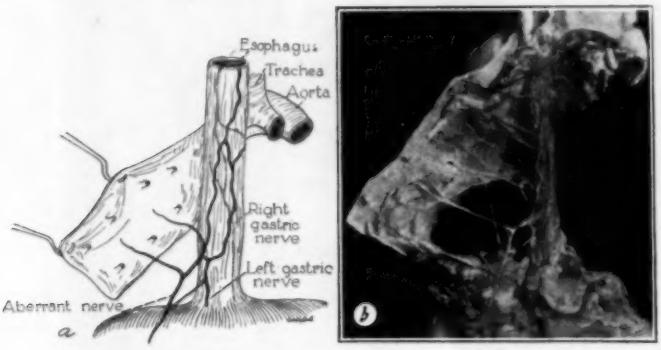

Fig. 5 *a* and *b*.—Another example of distribution of the gastric nerves in group 4.

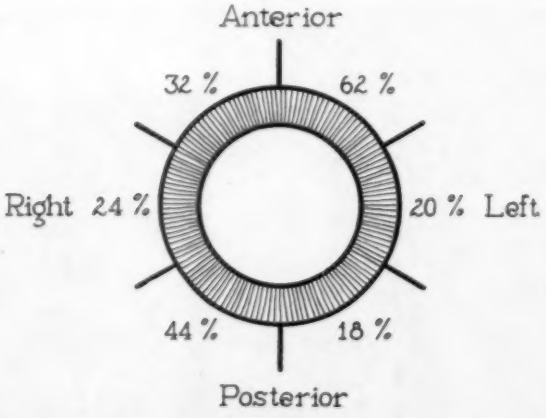

Fig. 6.—Relative position of the right and left gastric nerves about the esophagus at the level of the esophageal hiatus.

hiatus (fig. 3 *a* and *b*). There were 7 such cases. The remaining 8 cases made up the fourth group. In this group the nerves did not have a consistent or uniform course or pattern. In some cases well formed trunks were present, but somewhere near the diaphragm a well defined branch would leave the main trunk and course laterally in the thorax and lose its identity before leaving the thorax (fig. 4 *a* and *b*). In other cases the numerous branches of the esophageal plexus

failed to form into common trunks on one or both sides of the esophagus (fig. 5 *a* and *b*). In such cases the multiple small fibers followed their course along the esophagus; some passed through the esophageal hiatus, and some ran laterally in the thorax. In such cases as these, we were never certain of the distribution of every fiber of the right and left gastric nerves. Hence, in cases of this type section of all the gastric nerves might prove difficult for the surgeon.

As the trunks passed through the esophageal hiatus, we noted the relative position of the right and the left trunk about the esophagus (fig. 6). The course of the nerves was strikingly constant below the esophageal hiatus. The right gastric nerve, the larger in 54 cases, coursed posteriorly and to the left. After running about 3 to 5 cm., this nerve divided into numerous branches. One of these branches followed the lesser curvature of the stomach as far as the incisura, and another large branch followed the left gastric artery. We did not carry our routine dissections beyond the division of the right gastric nerve into these branches.

The course of the left nerve in the abdomen was short. As the nerve came to lie on the anterior surface of the stomach it divided into numerous small branches, which lost their identity in the serosa and the musculature of the stomach. Occasionally a small communicating branch between the right and the left gastric nerve could be identified at the esophageal hiatus.

CLINICAL STUDIES

The clinical application of these anatomic studies to the treatment of peptic ulcer has been made in 66 cases[7] at the Mayo Clinic (tables 1 to 8) and has led one of us (W. W.) to believe that the best approach to the gastric nerves is by an incision in the upper part of the abdomen. This approach permits exploration of the contents of the abdomen, examination of the ulcer and its removal if it is a gastric ulcer and is suspected of being malignant. Also, this approach permits some type of drainage of the stomach if an obstructive duodenal ulcer is present or if a duodenal ulcer is present that is likely to become obstructive with the occurrence of gastric atony after gastric neurectomy. Patients with ulcers of the types just mentioned usually have failed to respond to many attempts at nonsurgical (medical) treatment. The abdominal approach is also useful in cases in which a gastrojejunal ulcer has followed gastroenterostomy, for not infrequently repeated ulceration at the stoma has resulted in obstruction and reactivation of the duodenal ulcer. In such cases, removal of the gastrojejunal

7. Dr. Walters' assistants, Drs. Fitzgibbons, Watts, McVicker, Brownson, Lowe and Lyman, assisted in reviewing and abstracting the case records and in tabulating the results.

ulcer and disconnection of the gastroenteroanastomosis are advisable in addition to gastric neurectomy. If obstruction of the duodenum has resulted from reactivation of the duodenal ulcer or from its healing after the gastroenterostomy, pyloroplasty also is indicated. In a case in which an ulcer recurred after gastric resection performed elsewhere, perforation of the anastomotic ulcer into the colon was impending at the time of operation. In this case we felt that a more extensive

TABLE 1.—*Clinical Data on Authors' Ten Cases in Which Gastric Neurectomy (Vagotomy) Only Was Performed*

Case	Lesion	Total and Free Acids (Degrees); Gastric Contents, Cc.		Minimal Blood Sugar, Mg. per 100 Cc.	Curve for Insulin Test	Roentgenologic Findings	Comment and Results
		Before Operation	After Operation				
1	Gastrojejunal ulcer	28/12 45 cc.	40/0 40 cc.	20	Flat	.....	Good relief
2	Gastrojejunal ulcer	32/16 60 cc.	12/0 75 cc. (night)	33	Flat	Moderate delay in emptying	Excellent relief
3	Gastric ulcer	.....	26/0 60 cc. (night)	53	Flat	Atonic stomach; considerable secretion	Good relief early, but persistence of retained secretions
4	Gastric ulcer	.....	20/0 500 cc. (night)	22	Downward	Normal motility	Good relief
5	Bleeding duodenal ulcer	.....	10/0	..	.....	.....	Retention of 900 to 2,300 cc. 4 to 9 days after operation
6	Duodenal ulcer	64/54 75 cc.	6/0 141 cc. (night)	23	Downward	.....	Dramatic relief
7	Duodenal ulcer	46/24 150 cc.	40/28 100 cc.	7 (incorrect)	Upward	.....	Good relief
8	Duodenal ulcer	56/46 115 cc.	14/0 10 cc.	76	Upward	Normal	Good relief
9	Duodenal ulcer	60/40	20/0 50 cc.	..	.....	Duodenal ulcer with no crater; normal motility	Good relief
10	Duodenal ulcer	64/52 130 cc.	34/20 450 cc. (night)	28	Downward	Considerable secretion in stomach	Good relief

gastric resection was indicated, with removal of the anastomotic ulcer, even though gastric neurectomy was done also.

It is easy to understand, therefore, why gastric neurectomy was done without any additional sugical procedure on the stomach in only 10 of the 33 cases in which one of us (W. W.) performed gastric neurectomy and in 13 of 33 cases in which operation was performed by other surgeons. Since gastroenterostomy and partial gastrectomy without gastric neurectomy in the treatment of patients with peptic ulceration have been followed by relief of pain, decrease of night secre-

TABLE 2.—*Clinical Data in Cases in Which Gastric Neurectomy and Gastroenterostomy Were Performed Simultaneously*

Case	Type of Gastro-enterostomy	Lesion	Total and Free Acids (Degrees); Gastric Contents, Cc.		Minimal Blood Sugar, Mg. per 100 Cc.	Curve of Insulin Test	Roentgenologic Findings	Comment and Results
			Before Operation	After Operation				
11	Posterior	Duodenal ulcer with obstruction	70/56, 375 cc.	26/16, 30 cc.	32	Downward	.....	Excellent relief
12	Posterior	Perforating duodenal ulcer	98/88, 150 cc.	.....	..	.....	.....	Good relief
13	Posterior	Hemorrhagic duodenal ulcer with obstruction	78/66, 275 cc.	10/0, 370 cc.	..	.....	Normal	Good relief
14	Posterior	Perforating duodenal ulcer	70/54	.....	..	.....	.....	Good relief
15	Posterior	Perforating duodenal ulcer with obstruction	80/68	16/0, 100 cc.	..	.....	Normal	Good relief
16	Posterior	Perforating duodenal ulcer with obstruction	80/60	40/0, 60 cc. (night)	32	Downward	Gastrospasm	Good relief
17	Posterior	Duodenal ulcer	46/30, 17 cc.	16/0, 600 cc. (night)	50	Flat	Normal	Good relief
18	Posterior	Duodenal ulcer with obstruction	78/54, 200 cc.	8/0, 13 cc.	22	Flat	Dilatation with retained secretions	Slight fulness with food; good relief of symptoms
19	Posterior	Penetrating, bleeding duodenal ulcer with obstruction	.....	34/22	..	.....	Rapid emptying of stomach; delay in small bowel	Ileus; exploration; retention of 800 cc. of secretion
20	Posterior	Duodenal ulcer with obstruction	66/54, 100 cc.	22/16, 100 cc.	..	.....	Deformed duodenum; gastroenterostomy free but high	Retention of 2,000 cc. 4 to 14 days after operation; recurrence, pain and vomiting
21	Posterior	Duodenal ulcer	32/18, 500 cc.	14/0, 300 cc. (night)	45	Flat	Edema at anastomosis	Slight fulness with meals; good relief
22	Anterior; enteroanastomosis later	Duodenal ulcer with obstruction	60/50, 175 cc.	46/26	..	.....	Obstruction for 14 days	Obstruction for 26 days; good relief
23	Anterior	Duodenal ulcer with obstruction	60/40	64/54, 200 cc.	..	.....	Considerable retention	Retention of 900 cc. 4 days after operation; poor relief

tion, reduction of gastric acidity and relief of gastrospasm, the difficulties of determining the effect of an associated gastric neurectomy are evident, both from the subjective and the objective standpoint. Conse-

TABLE 3.—*Clinical Data in Cases of Gastric Neurectomy with Simultaneous Operation on Stomach*

Case	Lesion	Total and Free Acids (Degrees); Gastric Contents, Cc. Before Operation	Total and Free Acids (Degrees); Gastric Contents, Cc. After Operation	Minimal Blood Sugar, Mg. per 100 Cc.	Curve of Insulin Test	Roentgenologic Findings	Comment and Results
		Gastroenteroanastomosis Disconnected; Ulcer Excised					
24	Gastrojejunal ulcer	.....	20/6 125 cc. (night)	30	Flat	Slight deformity of duodenal cap; jejunitis in proximal part of jejunum	Excellent relief
25	Gastrojejunal ulcer	58/42 200 cc.	10/0 80 cc. (night)	43	Downward	.....	Excellent relief
		Gastroenteroanastomosis Disconnected; Ulcer Excised; Heineke-Mikulicz Pyloroplasty					
26	Malfunctioning stoma with obstruction	72/60 55 cc.	84/50 150 cc. (night)	30	Downward	Gastric pyloric spasm	Good relief
		Gastroenteroanastomosis Disconnected; Ulcer Excised; Finney Pyloroplasty					
27	Gastrojejunal ulcer	54/40 200 cc.	60/36 800 cc. (night)	20	Downward	Duodenum deformed by previous ulcer; stomach slightly atonic	Early retention; gradual decrease in 4 to 6 days; good relief
		Gastroenteroanastomosis Disconnected; Anterior Polya Resection					
28	Gastrojejunal ulcer	24/10 104 cc.	6/0 50 cc.	..	.....	Free anastomosis; bowel normal	Good relief
		Duodenal Ulcer Excised; Gastroduodenostomy					
29	Duodenal ulcer	66/48 200 cc.	22/0 325 cc. (night)	36	Flat	.....	Good relief
		Biopsy of Ulcer and Cautery					
30	Gastric ulcer	12/0	22/0 50 cc. (night)	..	.....	.....	Good relief
		Transthoracic Exploratory Gastrotomy; Biopsy of Gastric Ulcer; Gastric Closure					
31	Gastric ulcer and duodenal ulcer	64/52	22/0 800 cc. (night) 11/11/46; 40/26 250 cc.	45	Downward	Recurrence of ulcers, but essentially normal emptying of stomach	Moderate early retention; poor result
		Gastric Ulcer Explored					
32	Gastric ulcer; healed duodenal ulcer	50/34 150 cc.	28/0 200 cc.	45	Upward then downward	Normal	Good relief
		Exploratory Gastrotomy Only					
33	Gastritis	54/42 280 cc.	8/0 40 cc.	76	Upward	Normal	Good relief

quently, patients on whom no simultaneous operation is performed on the stomach are best to study in order to evaluate the results of gastric neurectomy.

TABLE 4.—*Data in Significant Cases of Gastric Neurectomy (Vagotomy) Performed by Other Surgeons*

Case	Transthoracic Approach for	Free and Total Acids (Degrees), Gastric Contents, Cc.		Minimal Blood Sugar, Mg. per 100 Cc.	Curve of Insulin Test	Roentgenologic Findings	Comment and Results
		Before Operation	After Operation				
34	Gastrojejunal ulcer	54/46 185 cc.	20/0 210 cc.	..	.....	.....	Excellent relief
35	Gastrojejunal ulcer	62/52 100 cc.	14/0 90 cc.	37	Flat	No ulcer; temporary delay in jejunum	Good relief
36	Gastrojejunal ulcer	36/26 105 cc.	18/0 80 cc.	..	.....	Free anastomosis; no gastrojejunal ulcer	Good relief
37	Gastrojejunal ulcer	1944: 112/100 150 cc. 1945: 40/20 100 cc.	12/0 50 cc.	..	.....	.....	No pain; slight tendency to diarrhea
38	Duodenal ulcer	60/46 130 cc.	50/28 200 cc.	38	Downward	.....	Good relief
39	Duodenal ulcer	78/68 100 cc.	5/31/46: 26/12 320 cc. 6/1/46: 62/50 150 cc.	..	.....	.....	Early retention; good relief; considerable eructation
40	Duodenal ulcer (abdominal approach)	74/56 150 cc.	40/20 40 cc.	..	.....	.....	Early retention; intermittent vomiting and diarrhea

TABLE 5.—*All Cases of Gastric Neurectomy Performed at Mayo Clinic Up to Nov. 1, 1946*

Type of Operation	Total No. of Cases	Duodenal Ulcer	Gastrojejunal Ulcer	Gastric Ulcer	Gastritis
Gastric neurectomy only.....	23	11	10	2	0
Gastric neurectomy with gastroenterostomy....	29	29	0	0	0
Gastric neurectomy with excision of ulcer.....	14	4*	7†	3*	1
Total number of cases.....	66	44*	17†	5*	1

* Both duodenal and gastric ulcer in 1 case.
† Gastrojejunocolic fistulas in 2 cases.

TABLE 6.—*Authors' Cases of Gastric Neurectomy Performed Up to Nov. 1, 1946*

Type of Operation	Total No. of Cases	Duodenal Ulcer	Gastrojejunal Ulcer	Gastric Ulcer	Gastritis
Gastric neurectomy only.....	10	6	2	2	0
Gastric neurectomy with gastroenterostomy.....	13	13	0	0	0
Gastric neurectomy with excision of ulcer.....	10	2*	5	3*	1
Total number of cases.....	33	21*	7	5*	1

* Both duodenal and gastric ulcer in 1 case.

RESULTS OF GASTRIC NEURECTOMY

The results in the 10 cases in which one of us (W. W.) performed gastric neurectomy without other surgical procedures on the stomach were satisfactory in so far as they were measured by relief of pain, reduction of gastric acidity and gastric secretion (table 1). One patient

TABLE 7.—*Complications Following Gastric Neurectomy in Thirty-Three Cases (Other Surgeons)*

Type of Operation	Total No. of Cases	Retention		Results	
		Early Clinical	Roentgenologic	Cases	Type
Gastric neurectomy only	13	2	1	1	Early pleural effusion; epigastric distress
				1	Recurrent abdominal pain
				1	Tendency to slight diarrhea
				1	Early retention, followed by intermittent emesis and diarrhea
				1	Considerable belching
				1	Death on fourth postoperative day; probably pulmonary embolus
Gastric neurectomy with gastroenterostomy	16	3	0	1	Death on fourteenth postoperative day from perforated duodenal ulcer and subdiaphragmatic abscess
Gastric neurectomy with excision of jejunocolic fistulas	2	0	0	1	Death of unknown cause three months after operation
Excision of duodenal ulcer	2	0	0	1	Recurrent pain at night

TABLE 8.—*Relation of Free Gastric Acidity to Type of Gastric Operation (Authors' Cases)*

Type of Operation	Total No. of Cases	Acidity Before Operation		Acidity After Operation	
		Determinations Made, Cases	Mean Value, Units	Determinations Made, Cases	Mean Value, Units
Gastric neurectomy only	10	7	30.0	10	2.8
Gastric neurectomy and gastroenterostomy	13	12	53.2	11	12.2
Gastric neurectomy and excision					
Gastrojejunal ulcer	5	4	38.0	5	18.8
Gastric ulcer	3	3	20.0	3	0
Duodenal ulcer	1	1	48.0	1	0
Gastritis	1	1	42.0	1	0
All cases	10	9	33.6	10	9.4
Grand total	33	28	41.1	31	8.3

(case 3, table 1) who was operated on for a gastric ulcer complained of a sensation of fulness after eating small amounts of food. At the time of this report, several weeks after operation, he continues to have a dilated stomach with pylorospasm, retention of considerable gastric secretion and hypomotility of the intestine. There was so much fluid in the stomach that the roentgenologist could not see whether the ulcer had healed. In 8 of these 10 patients relative achlorhydria

followed the operation. Relative achlorhydria also developed after operation in 6 of 11 cases of duodenal ulcer in which simultaneous gastroenterostomy and gastric neurectomy were performed and tests of acidity were made (table 2). This incidence of achlorhydria contrasts favorably with an incidence of 12 per cent in a series of cases of gastroenterostomy which I reported several years ago.[8] In 4 of the 5 remaining cases gastric acidity was reduced. The insulin test, however, was not carried out to confirm the completeness of neurectomy in the fifth case, and the patient was only partially relieved of his symptoms. In 1 of our 33 cases (tables 1, 2 and 3) a large gastric ulcer recurred, and in 1 of 33 cases in which the operation was performed in other services at the clinic a duodenal ulcer perforated, with development of a subdiaphragmatic abscess, and death occurred on the fourteenth day after gastric neurectomy and gastroenterostomy. Retention of gastric secretion and severe hypoproteinemia were also present. In this case, also, the insulin test to confirm the completeness of the neurectomy was not made, and postmortem examination of the gastric nerves to ascertain the completeness of the neurectomy, unfortunately, was omitted.

Postoperative disturbances of gastrointestinal motility were troublesome in 6 of our 23 cases (tables 2 and 3) in which additional operations on the stomach were performed simultaneously. Characteristic of 3 of these 6 cases was intermittent paroxysmal distention of the abdomen, which was relieved by injections of neostigmine methylsulfate. In 1 of the 3 cases (case 19, table 2) distention appeared on the fifth day after operation and increased during the next two days. Roentgenologic examination of the abdomen revealed what seemed to be obstruction of the small intestine, and exploratory operation revealed ileus; the small intestine was filled with fluid and air or gas, and there was approximately 800 cc. of sterile, straw-colored fluid within the peritoneal cavity. Continuous gastric suction with an indwelling nasal suction tube relieved the distention in this case, and normal intestinal motility returned. Two of the 6 patients had clinical symptoms of gastric retention and required intermittent drainage with a gastric tube from the fourth to the eleventh day after operation. An additional patient (case 22, table 2) had gastric retention for twenty-six days, which required jejunojejunostomy for relief. Reduction in gastric acidity and night secretion in both groups of cases are shown in tables 1 to 4. In many cases in each group, postoperative studies of gastric motility and roentgenoscopic and roentgenographic examinations were made after the patient left the hospital, on approximately the

8. Walters, W.: Gastric Acidity Following Operations for Gastric and Duodenal Ulcer: Its Effect on the Question of Partial Gastrectomy, Ann. Surg. **104**:585-593 (Oct.) 1936.

fourteenth to the twentieth postoperative day. In 10 of the 33 cases in which one of us (W. W.) performed gastric neurectomy temporary disturbances of gastric motility with retention of gastric secretion occurred. In 1 case, as mentioned previously, these symptoms persisted for several weeks (case 3, table 1). In 2 of our colleagues' 13 cases in which gastric neurectomy alone was performed intermittent diarrhea has occurred since the operation.

Insulin Test.—On evaluating results of gastric neurectomy, it is, of course, important to determine that all the gastric (vagus) nerves have been divided. Unfortunately, the insulin test, described by Hollander [9] to determine whether complete division of the gastric nerves has been accomplished, involves some risk and must be made only under the constant supervision of a physician who has dextrose available for immediate administration if symptoms of hypoglycemic convulsions manifest themselves. The test itself consists of injection of 10 to 30 units of insulin, in order to reduce the patient's blood sugar to 40 mg. or less per hundred cubic centimeters. If branches of the gastric nerves are intact, an increase in the gastric secretion occurs in from forty to fifty minutes after injection of the insulin.

COMMENT

Seventeen years ago, in the Division of Experimental Surgery and Pathology of the Mayo Foundation, studies were made by Hartzell [10] and Vanzant [11] on the effects of intrathoracic and abdominal section of the vagus nerves in dogs. Hartzell first studied 8 animals, 6 after intrathoracic vagotomy and 2 after abdominal vagotomy. Immediate observations showed total abolition of psychic secretion (cephalic phase) with pronounced and constant reduction of free hydrochloric acid and total acidity and an increase in the hydrogen ion concentration. Vanzant studied 4 of the same dogs two and a half years later and found that the dogs of the original group had an increase in the amount of total and free acid after five to six months. Eventually, the curves of free and total acid approached normal. In 1 dog the acidity was slightly increased above normal levels, and in 3 dogs there was moderate, but not complete, restoration to the normal level of acidity. This return of gastric acidity also occurred clinically in 1 of the patients operated on at the clinic. At first, a relative achlorhydria was present after opera-

9. Hollander, F., in discussion on papers by Drs. Berk and Frediani, Ivy and Dragstedt, and others, Gastroenterology **3**:466-467 (Dec.) 1944.

10. Hartzell, J. B.: The Effect of Section of the Vagus Nerve on Gastric Acidity, Am. J. Physiol. **91**:161-171 (Dec.) 1929.

11. Vanzant, F. R.: Late Effects of Section of the Vagus Nerves on Gastric Acidity, Am. J. Physiol. **99**:375-378 (Jan.) 1932.

tion. With a return of gastric acidity to the preoperative level symptoms of ulcer recurred. Unfortunately, the insulin test was not made; so we do not know whether all the gastric nerves were resected.

Effects on motility were observed to be inconstant in a study on 10 dogs made by Vanzant.[12] Early studies showed that 4 dogs had delayed emptying of the stomach, 2 dogs had gastrointestinal hypermotility with a tendency to diarrhea and emesis and 3 dogs had no change in the emptying time of the stomach. Later, after operation, essentially normal gastrointestinal motility was observed in 7 dogs. One dog had rapid emptying of the stomach; 1, a slight delay, and 1, pronounced delay. No bad effects on the general health followed the operation on 6 dogs except for excessive salivation, which gradually decreased. Two dogs vomited frequently after the operation. Three dogs had increased appetite, in spite of which loss of weight was noted.

Dragstedt[13] treated his first patient with gastric neurectomy three and a half years ago, and Moore, Chapman and associates[14] treated theirs more than two years ago. Most of the more recent patients treated by these surgeons have so far been benefited. The same is true in the series of cases reported by Grimson and his associates.[15] Yet, because of experimental evidence that changes in gastric acidity and motility after vagotomy may be only temporary, and because long experience with peptic ulcer makes us reserve our judgment concerning any operation until a large series of patients have been watched for many years, gastric neurectomy is being performed at the Mayo Clinic in selected cases of peptic ulcer only. We think that the final report on this operation is not due for several years and that all reports now, and for some years to come, should be considered interim reports.

In the meantime the procedure can be used in certain types of cases: 1. In cases of recurring ulcer after adequate gastric resection it seems justifiable to offer the patient the comparatively simple operation of gastric neurectomy on the chance that the ulcer will heal and he will obtain relief of symptoms. 2. Possibly, in certain cases of gastric ulcer in which excision of the ulcerating lesion and microscopic examination

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12. Vanzant, F. R.: The Late Restoration of Gastric Acidity After Thoracic Vagotomy in the Dog, unpublished data; footnote 11.

13. Dragstedt, L. R.: Vagotomy for Gastroduodenal Ulcer, Ann. Surg. **122**: 973-989 (Dec.) 1945.

14. Moore, F. D.; Chapman, W. P.; Schulz, M. D., and Jones, C. M.: Trans-Diaphragmatic Resection of the Vagus Nerves for Peptic Ulcer, New England J. Med. **234**:241-251 (Feb. 21) 1946.

15. Grimson, K. S.; Taylor, H. M.; Trent, J. C.; Wilson, D. A., and Hill, H. C.: The Effect of Transthoracic Vagotomy upon the Functions of the Stomach and upon the Early Clinical Course of Patients with Peptic Ulcer, South. M. J. **39**:460-471 (June) 1946.

are necessary to exclude the possibility that the ulcer is malignant, gastric neurectomy is advisable if the ulcer is benign. Yet in 1 of our cases troublesome symptoms referable to gastrointestinal motility, with gastric retention and pyloric obstruction, followed this procedure (case 3, table 1). 3. In certain cases of duodenal ulcer with hyperchlorhydria, gastric neurectomy with simultaneous gastroenterostomy to relieve the duodenal obstruction may be advisable. It will be interesting to see whether the incidence of recurring ulcer will be less than it is in cases in which gastroenterostomy only is performed. 4. In cases of chronic, nonobstructive duodenal ulcer, in which the cephalic phase of the hyperacidity seems to overshadow other factors and repeated courses of medical treatment have not given any relief, we believe that gastric neurectomy may be justified. Many of the patients with ulcer of this type are young and have high values for gastric acidity and active duodenal ulcers, and their behavior pattern suggests a prolonged and excessive nervous phase of gastric secretion.

SUMMARY AND CONCLUSIONS

There is considerable variation in the position, number, size and distribution of gastric nerves above the diaphragm. In 92 per cent of the adults studied, however, the gastric nerves, after piercing the diaphragm, appear as discrete trunks and are readily accessible for surgical removal by the transabdominal approach.

A study of 66 cases in which gastric neurectomy was done at the Mayo Clinic indicates that gastric acidity was reduced in most cases. Relief of symptoms of pain was not strikingly different from that obtained with rest in bed and established surgical procedures. Interpretation of the results of gastric neurectomy should be restricted to that group of cases in which the procedure is carried out without any simultaneous operation on the stomach. There were 23 such cases in our series.

A large gastric ulcer recurred in a case in which relative achlorhydria occurred immediately after operation. A few weeks after operation free hydrochloric acid was found to be present in the stomach. Symptoms of ulcer returned, and roentgenologic examination revealed recurrence of a large gastric ulcer which had been partially excised for microscopic examination at the time of transthoracic resection of the vagus nerve. Perforation of a duodenal ulcer with subdiaphragmatic abscess and death occurred fourteen days after operation in 1 of our colleagues' cases in which gastric neurectomy and gastroenterostomy were performed. In 2 other cases death occurred, in 1 on the fourth day after operation, from a suspected cerebral embolism, and in the other three months after operation at home, from coronary occlusion. In the

latter case a gastrojejunocolic fistula closed and gastric neurectomy was performed. In another case there was a return of gastric acidity with recurrence of symptoms of ulcer. Unfortunately, the insulin test was not made to determine the completeness of neurectomy.

In several cases disturbances of gastrointestinal motility occurred during the patient's stay in the hospital; in 1 case it has persisted for several weeks. In 1 case a secondary jejunojejunostomy was required. In 1 case exploration was made for a suspected intestinal obstruction and ileus was observed, and in 2 cases intermittent diarrhea had persisted since operation.

Some method of testing to ascertain that all branches of the vagus nerves are divided is essential. The present method is the insulin test of Hollander, which must be carried out with great caution.

In view of the return of gastric acidity and gastrointestinal motility to normal or near normal in most experimental animals after an interval of two years, the possibility of the same result among human beings must be recognized. Hence, all reports on clinical results should be considered as interim reports until sufficient time elapses to determine whether a return of gastric acidity, motility and secretion to about preoperative levels occurs, with possibility of the formation of new ulcers.

To date, in the small series of 33 cases in which one of us (W. W.) employed gastric neurectomy, we have been impressed with the reduction of gastric acidity and the relief of pain which have followed complete gastric neurectomy, and we believe that the operation has merit, though the results may be temporary. The frequency of troublesome disturbances in gastrointestinal motility; the recurrence of ulceration in 1, and possibly in 2, cases; perforation of a duodenal ulcer after gastric neurectomy and gastroenterostomy in 1 of our colleagues' cases; the uncertainty of ultimate good results; the possibility of undesirable results not now evident; the necessity of performing additional procedures, such as gastroenterostomy, to relieve duodenal obstruction; the necessity of excision of ulcerating gastric lesions to exclude the presence of a malignant growth, and the death of 3 of the 66 patients indicate that we must continue to study the problem of the treatment of peptic ulcer, and not attempt to draw conclusions regarding the ultimate value of gastric neurectomy until more cases have been studied and a longer time has elapsed after operation.

Gastric neurectomy offers a method which gives great promise in the treatment of patients with recurring ulcer, especially after gastric resection and gastroenterostomy, and in the results to date in cases of this type gastric neurectomy has justified itself as a useful and important procedure. If it will prevent recurring ulceration after gastroenterostomy, it has further justified its value.

DISCUSSION ON PAPERS BY COLONEL HAMILTON AND DRS. WALTERS, THOMPSON AND OTHERS

DR. ERWIN SCHMIDT, Madison, Wis.: This paper is of importance because of advances in radiation and atomic energy and the application of these forces to clinical use. Demonstrations such as this call attention in a dramatic way to the dangers associated with the application of these new potentia.

Boyd's description of the effect of radiation energy has appealed to me, with its suggestion of certain clinical limitations. On the pathologic cells there are caustic and lethal effects. On the host, which furnishes the bed for the pathologic tissue, there is also an effect. The radiation energy acts on the pathologic cells, and also on the normal cells through which the radiation must pass. This leads to destruction of tissue, both pathologic and normal. Healing must take place through inflammation and fibrosis. If enough energy is present to kill malignant cells, normal cells are killed also.

Irradiation of the gastrointestinal tract has not been used except in cases in which the pathologic process is fixed. Such a lesion often responds because some of the fixation is due to inflammation, which responds favorably to radiation. This is particularly so in the sigmoid and the rectum. Lesions in the gastrointestinal tract, except for carcinoma of the rectum, are usually not amenable to radiation. In the rest of the tract, adequate radiation to the anaplastic cells would damage the bowel, as amply demonstrated by Colonel Hamilton. Some malignant cells, such as those of lymphosarcoma, are more sensitive, and so a smaller dose causes the tumor to disappear and does not injure the bowel and the surrounding structures.

My colleagues and I have had no experience, such as the author describes, with acute hemorrhage and perforation of radiation ulcer. We have seen similar changes in the small bowel, such as those which occur in cases of carcinoma of the rectum in which heavy radiation has caught a loop of the intestine or in cases of inoperable tumor in which attempt has been made to control the anaplastic lesion with irradiation.

The pathologic picture in the stomach as described by the author is similar to that familiar in reactions to roentgen radiation—the acute stage, in which gastroenteritis develops during the treatment, and the later stages, eventually leading to necrosis. The experience of the plastic surgeon that excision of normal tissue is necessary to obtain healing demonstrates that the area affected is usually as wide as the area treated. I do not feel that one must postulate a toxin or assume that the ulcer is similar to the ulcer of the duodenum described by Curling. Local damage to tissue is sufficient; and the superficial necrosis following roentgen irradiation suggests local damage.

DR. EDWIN M. MILLER, Chicago: I am sorry that Dr. Dragstedt cannot be here to discuss Dr. Walters' papers, for one has to look to the evidence presented by Dr. Dragstedt, both experimentally and clinically, for the most reliable data on this subject to date. It is well for the members of this society to take the proper attitude toward the problem of this operation and to realize that it is still in the formative stage (experimental stage, one might say) and that it is not fair to make too definite statements regarding the end results. The pendulum will eventually swing back, and only time will evaluate the procedure devised by Dr. Dragstedt and determine its permanent merit.

I had the opportunity to read Dr. Walters' paper this morning and to go over his slides and drawings; it seems to me that his studies at the Mayo Clinic and the

statements in his paper are sound, reasonable and backed up by careful study. It is well for all of us who are interested in this problem to evaluate the evidence, without exaggeration, so that in due time we may accumulate data of permanent value.

My colleagues and I became interested in this problem a year or so ago, and we felt that before we could undertake operation on patients we must first investigate the problem from the anatomic standpoint. One would not think of performing extensive operations on the biliary tract, for instance, without having done considerable investigation of the anomalous structures which one might encounter in this region of the common duct, the cystic duct, the cystic artery and the right hepatic artery. The same might be said of anatomic studies on the neck, to determine the possible anomalous relations of the inferior thyroid artery, the parathyroid glands and the recurrent laryngeal nerve.

Therefore, we turned to the laboratory for this information and undertook a series of dissections. It soon became apparent that cadavers were not suitable, because in isolating delicate nerves, like the branches of the vagus, it was important to make the dissection on fresh bodies. Therefore, with the permission of the department of pathology of the University of Chicago, Dr. Carl Davis Jr. and I went to the autopsy room and made a series of studies of the vagus nerves from the pulmonary plexus down to the termination of the branches in the walls of the stomach. We concluded that there is considerable variation in the distribution of the vagus nerves; in fact, there is hardly any uniformity of distribution. A fair example of what one may encounter at operation may be seen on the first slide, taken from Spalteholz' "Anatomy."

In section of the vagus nerves, it is important to divide not only the main trunks but also the several branches which may be accessory; therefore, the logical surgical approach is probably through the chest, where one has a fine exposure, a good view of the whole situation and a bloodless field in which to isolate the accessory branches. However, I may be wrong about that, for Dr. Walters has used the abdominal approach almost exclusively and Dr. Dragstedt of late, I think, also confines his approach to the subdiaphragmatic route. In spite of this, I still feel as I did originally, that the easier and the more accurate approach is through the chest.

The next slide shows the results in our first 11 dissections; I wish to point out that in only 2 instances was the situation comparable to what might be considered a normal distribution of the nerves. Some of the branches hugged the esophageal wall closely, while others were widely separated; and in 1 or 2 cases the small branches were so close to the mediastinal pleura on the right side that in picking them up one might easily tear the pleura at that point.

If one approaches from below the diaphragm and brings down the esophagus on the hooked finger, one may at first go in between the esophageal wall and the vagus trunks and, after a vain search, may have to look deeper for (especially) the right, or posterior, trunk. Then, too, if one approaches from below, there may be a greater tendency to venous oozing in the field, for in some patients there is a considerable venous plexus in this area. But the approach from below the diaphragm obviously has its advantages: One can see the lesion in the duodenum or the stomach and can perform, if necessary, a gastroenterostomy or resection at the same time.

I should not attempt at this time to say anything about the end results of operation, for our series of cases are relatively small, both at the Presbyterian

Hospital and at the Veterans Hospital at Hines, Ill., and the time elapsed since our earliest operation has been only about one year. Certain things, however, stand out clearly in the postoperative picture. One is the feeling of "well-being" and freedom from distress that is observed soon after operation. In some cases there is a tendency toward cardiospasm and in others to pylorospasm, which may be troublesome for a time. In some cases there is a mild paralytic ileus; in others, a tendency toward diarrhea for several days. All these complications, however, are temporary and tend to pass away in a relatively short time. But the true answer to many of the questions will be found through a much longer study of the problem.

Dr. Harry B. Zimmermann, St. Paul: In watching Dr. Sanders operate on patients with gastric ulcer by resection of the vagus nerves, and in listening to the discussions, two things have struck me rather forcibly. One is that the surgeon does not operate for ulcer of the stomach unless the patient has had adequate medical management first. The second is that patients who have a vagotomy immediately experience a sense of well-being; not only are their symptoms of pain relieved but they feel fine. "I have not felt so well in years," said one of Dr. Sanders' patients. Dr. McNealy had the same experience.

Even if all the patients who have had vagotomies should have a recurrence of symptoms within five years, Dr. Dragstedt has nevertheless accomplished a great deal. He has proved something definite. Many other surgeons have demonstrated this effect of nerve impulses. Dr. Wangensteen, who advocates a considerable resection of the stomach, has proved to his own satisfaction that an exciting cause of the ulcer is excess of hydrochloric acid—not only an excess, but a continuance of the hydrochloric acid or gastric secretion in the stomach after the stomach has emptied itself. In other words, the gastric secretion continues beyond the normal period. Dr. Dragstedt, I think, has proved that if the nerve supply of the stomach is interrupted the sense of discomfort is at least temporarily relieved.

The other phase of the discussion, namely, that the patient must have had proper medical treatment before any surgical procedure is carried out, is obvious; but I have yet to learn what proper medical treatment is. I have a great deal of respect for Dr. Wangensteen's careful work on the physiology of the stomach, but he was not able to find that diet made one particle of difference. The patient got along just as well on raw carrots as on pap. That also has been true in my experience.

However, if one is to give proper medical treatment, one must take cognizance of the facts in Dr. Dragstedt's work and interrupt at their source, the cerebral cortex, the impulses to the stomach that are disastrous and are responsible for the continuance of gastric secretion. This brings me to the business of psychosomatic therapy. Before one can evaluate medical management, these patients must have their difficulties straightened out. Their tensions and their anxieties must be relieved.

"Proper medical treatment," so far as anxiety is concerned, has been something like this: "You take a dose of this pap every two hours. God help you if it doesn't do you any good, for then we are going to have to cut your stomach out." That is supposed to relieve the patient's anxiety!

I wish to repeat, all this work is extremely beneficial if one does not take too literally the New Testament mandate of cutting off the offending member.

Dr. Robert L. Sanders, Memphis, Tenn.: Being host of the association, I should be seen and not heard. Nevertheless, I appreciate the privilege of taking part in this discussion.

My colleagues and I have had only 15 cases; but, from the clinical results obtained thus far, I believe that vagotomy is on solid ground.

Dr. Zimmermann has emphasized the psychoneurotic factor in duodenal ulcer. If this is the primary factor, division of the nerve pathways should be sound therapy from the etiologic and physiologic, as well as from the clinical, standpoint. It serves to remove the stimulus which gives rise to gastric hypermotility, hypersecretion and hyperacidity, which, in turn, produce and maintain ulcer.

It is of little practical importance whether hyperacidity, hypersecretion or hypermotility is first in the synthesis of ulcer, though it is probable that hypermotility is first, since the symptoms are induced directly by pylorospasm. Moreover, other operations involving section of nerves, such as sympathectomy for dysmenorrhea, are based on the same principle: When the tissues are relaxed, the pain ceases. In a few of our cases we have made an observation which indicates that hyperacidity plays a lesser role; i. e., the postoperative acids may be little reduced, or not at all, under the stimulus of insulin hypoglycemia and yet the patient may be free of pain from his ulcer. One may assume that hypermotility is responsible for hypersecretion and that the latter is, in reality, chiefly active in the production and maintenance of ulcer. This is in accord with Dragstedt's view that the chief secretory abnormality is the production of an excessive amount of acid during periods of fasting, particularly at night.

In any event, vagotomy is a rational indirect attack on the ulcer. It gives one an idea of what might be accomplished by attack on the source of the ulcer, that is, by preventing stimulation of the nerve centers themselves. It may be that in the not far distant future some agent will be discovered which serves this purpose effectively and permanently.

Whether one employs the abdominal or the thoracic approach is an individual matter. Being an abdominal surgeon, I prefer to divide the nerve trunks through the abdomen. The thoracic surgeon feels that he can better reach them through the chest. At my age, I do not want to become a thoracic surgeon; I am going to stick to abdominal surgery. I want to look at the ulcer, to feel it and, if it is in the stomach, to find out whether or no it is malignant. If it is a duodenal ulcer, I want to see whether it is posterior or anterior or both, and whether it is producing obstruction or is likely to do so; if so, I want to do a gastroenterostomy.

I have had no difficulty in dividing the nerve trunks through the abdomen. Before attempting the procedure, I tried it on cadavers, using the abdominal approach; then I opened the chest to see whether all the trunks had been sectioned. I could not find any intact fibers anywhere. This convinced me that the operation could be performed as successfully through the abdomen as though the chest. Vagotomy should not be attempted by the untrained surgeon, however, as it is not always easy to isolate the nerve trunks. Furthermore, in some patients there are more than two vagus trunks, and one or more is likely to be overlooked.

Although I do not believe vagotomy is the final answer to the problem of ulcer, it seems to be preferable to gastrectomy in that the technic is relatively simple, the risk is less and nutritional disturbances are likely to be fewer. The nerves having been divided through their trunks and the ulcer having healed, one has good reason to expect that the symptomatic results will be lasting.

Dr. Charles W. Mayo, Rochester, Minn.: I rise to a point in question as to the existence of any method at present that is adequate to determine within two weeks after operation whether or not a surgeon has cut all the branches of the vagus nerve. In my opinion, the passage of time, at least to the point of two to four months, with tests for the absence of acids, is the only justifiable means of concluding that all branches of the vagus nerve have been resected.

Those of us who have done or are doing thyroid surgery have seen a condition known as traumatic temporary paralysis of the recurrent laryngeal nerve and have known the function of the nerve to return after a week, or sometimes as late as two to three months after operation.

Because a review of records made at present might otherwise lead to a source of error in future considerations of this subject, it should be emphasized that sufficient time must elapse before it can be recorded that all nerves were cut at operation.

DR. R. RUSSELL BEST, Omaha: I have been interested in the vagus nerve for several years. In fact, about fifteen years ago I reported on some experiments. Since then, I have tried to follow the literature regarding the effect of the vagus on the gastrointestinal tract, and I am sorry to have to disagree with our genial host, but I do not believe that vagotomy as a treatment of gastric ulcer is fundamentally sound.

In experiments carried out fifteen years ago, in which I tried to determine whether peptic ulcer is lymphogenic or neurogenic, I injected staphylococci into the wall of the stomach, in an attempt to produce ulcers in rabbits. I found out that these rabbits died of a very small injection of staphylococci within about four days. Examination of the nerve did not show vagitis or any disturbance of the lymphatic system.

I then conducted experiments on dogs in which I laid strips of magnesium sulfate on the vagus nerve in the neck in the hope that I might produce the ulcer which Cushing had presented as secondary to tumor of the brain.

However, when I placed the strips of magnesium sulfate on both vagus nerves of the neck, the dogs, unfortunately, died. Four died because the strips were placed on both nerves, thus blocking the heart; I knew, therefore, that I was stimulating the vagus nerves.

In the next 6 dogs, I made gastric pouches and laid the strips on one nerve, but I was unable to produce ulcer. I then lost my interest in the relation of the vagus nerve to the stomach. Since then, a great deal of research has been done; I believe that it might well be summarized in the statement by Cryder and Thomas, in their recent report on their experiments. They found that within two years all their animals had a return of normal pancreatic secretion after section of the vagus nerves.

This observation probably leads to the conclusion that the stomach or the gastrointestinal tract is autonomous. That is, after the vagus nerves are cut, the patient can still eat, he still has gastric juices and the stomach empties. I do not believe one should try to arrive at a conclusion about this operation before another three or five years. Many surgeons will probably become more enthusiastic about vagotomy or vagectomy, but I believe one should withhold the expression of any definite opinion at this time.

DR. FRANK HAMILTON, Washington, D. C.: The series of postradiation gastric ulcers is too small to permit conclusions as to the etiologic factors. There seems to be a direct relation between a heavy dose of radiation delivered to the region of the stomach and the formation of a radiation ulcer. There also appears to be an individual tumor sensitivity, as well as a personal sensitivity, to the effects of radiation. However, radiation ulcer did not develop in any patient who had a dose of less than 5,000 r applied to any one area. Since the arbitrary limitation of the dose to this amount, no new radiation ulcers have appeared at this hospital. My colleagues and I, however, are still seeing, and operating in, occasional cases of excessive fibrosis with intestinal obstruction following heavy doses of radiation. How long we shall continue to see cases of this type is a matter of conjecture.

In answer to Dr. Schmidt's question concerning necrosis at the site of anastomosis: Fortunately, in my small series, I have not yet encountered that complication. Perhaps one reason is that I have always been able to make the anastomosis through reasonably normal tissue. On the gastric side of the anastomosis, the effect of radiation seems to be sharply limited, and I have always been able to resect the stomach through normal tissue at a higher level than that at which the radiation effect apparently exists, as shown by the slides. On the jejunal side of the anastomosis, I have always been able to find a reasonably normal-appearing loop of jejunum which was used for the anastomosis. This anastomosis was followed by a jejunojejunostomy when indicated. At any rate, thus far none of the anastomoses have broken down; but, again, it must be emphasized that the series is small and definite conclusions cannot be drawn.

DR. WALTMAN WALTERS, Rochester, Minn.: Dr. Mayo has brought out an important point which I had not considered previously. In the study of the results of the insulin test, the only deduction possible is that a rise in gastric secretion fifty minutes after injection of sufficient insulin to reduce the blood sugar below 40 mg. per hundred cubic centimeters indicates that all the branches of the vagus nerves have not been cut. This increase occurred in 1 of my cases and in some of the other cases which we have studied. I am glad that Dr. Best brought out the points which he did, for experimental evidence presented by Hartzell and Vanzant and others indicates rather definitely that gastric secretion and gastric acids return within two years after resection of the vagus nerves.

Why does the atonicity, which develops two, three or four days after gastric resection, and in some cases persists for two weeks, subside? This return to normal tone is probably to be explained by an inherent autonomic mechanism in the stomach, which is independent of the vagus nerve. Moreover, the histamine acts directly on the secretory mechanism of the acid-secreting glands of the stomach, but not on the vagus. This is an important factor in the necessity of a good dietary regimen which aims to lower and neutralize gastric acidity in cases of peptic ulcer. Certain substances, such as tobacco, alcohol and hot peppers, directly stimulate the gastric glands to secrete acid and do not act through the vagus nerves. It is well to remember, also, that only the central mechanism of gastric stimulation is removed when the vagus nerves are cut.

I wish to call attention to several cases and to show some slides. In 1 case I performed gastric neurectomy for a small gastric ulcer about nine weeks ago. The ulcer was not removed. The patient felt fine for two weeks after operation, at which time he returned home. He then began to have a feeling of fulness after meals and returned for further examination. A roentgenogram taken about 1 o'clock in the afternoon eight weeks after the operation revealed a dilated stomach. There was so much secretion in the stomach five hours after a test meal that the roentgenologist could not tell whether or not the ulcer had healed. Pylorospasm and hypomotility of the small intestine were noted on roentgenoscopic examination. In other words, the finely coordinated mechanism of the muscles of the stomach, the pylorus and the small intestine was absent.

In another case gastric neurectomy had been performed for a large gastric ulcer. The neurectomy had been complete, as determined by the insulin tests. The large gastric ulcer which the patient had prior to operation is shown in the roentgenogram (left side of slide), and a roentgenogram made several months later reveals the recurring gastric ulcer (right side of slide). The patient had achlorhydria after operation, but with recurrence of the ulcer the gastric acids reappeared in increasing amounts. He has also had bleeding from the ulcer.

I should like to mention the immediate relief of pain which is said to occur after gastric neurectomy. Many surgeons have noticed the relief of pain which occurs when a patient with an active, painful ulcer rests in the hospital for a time before operation. I found years ago that unless I told the patient before hospitalization that he would think he was cured at the end of a week in the hospital, before operation, he would want to leave the hospital and not stay for his operation.

Then, too, a certain degree of inflammation regresses spontaneously. To emphasize this point, I call attention to a number of patients with gastric lesions which the surgeon believed at the time of exploration to be inoperable and malignant. Seven-tenths per cent of these patients have lived longer than five years since exploration. In one-half the cases the lesion was proved to be malignant by biopsy. In the other half, no biopsy was made, and the lesion apparently was inflammatory and had healed spontaneously.

I have a three minute motion picture showing the technic of transabdominal gastric neurectomy. Yesterday Dr. Sanders called attention to the value of placing a tube in the esophagus. The procedure is helpful, but it is well to pull the tube up high in the esophagus after the main vagus trunks have been resected because it interferes with palpation of the smaller branches of the nerves on the esophagus. (Motion picture.)

There is a tendency for all nerve structures to regenerate. However, in some of Hartzell's and Vanzant's dogs examined two years after resection of the vagus nerves regeneration had not occurred.

It is my belief that if the vagus nerves can be accurately resected just above the diaphragm, they can be resected as well just below the diaphragm. In the 8 per cent of cases in which multiple nerves are present, it seems to me the same trouble in locating all the branches will be encountered with the thoracic as with the abdominal approach. The value of exploration of the ulcer and the other abdominal structures which is possible with abdominal approach cannot be minimized.

DR. HAROLD L. THOMPSON, Los Angeles: I have nothing to add except to call your attention again to the point that my paper is the factual report on a sampling from two and one-half years' work in gastric surgery at the Los Angeles General Hospital. The method was to take 100 unselected cases in one group and 50 unselected cases in another group. The results of this study are discussed in our article (Thompson, H. L., and Prout, H.: Surgical Treatment of Peptic Ulcer, Recent Experience at Los Angeles General Hospital, ARCH. SURG. **54**:390-413 [April] 1947).

THE MEDULLARY NAIL

Presentation of a New Type and Report of a Case

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INTRAMEDULLARY internal fixation in the form of wires or bone grafts has been used for many years. Küntscher in 1940 [1] was apparently the first to use a so-called nail or bar in the shafts of long bones which traversed the length and width of the canal, thereby controlling angulation, lateral displacement and torque. The original Küntscher nail is a V-shaped bar of V2A stainless steel of such a size as to be easily driven into the medullary canal of the particular bone under treatment.

In devising the medullary nail, Küntscher has produced a form of fixation for shaft fractures analogous to that supplied by the nails used so frequently and successfully in fractures of the femoral neck. His method therefore has the same advantages, i. e., no external fixation is necessary, the joints are kept mobile and the patient may be ambulatory in a relatively short time.

In the six years since Küntscher's original report this method has been used extensively in Europe, with gratifying results. Maatz and Reich [2] reported a series of over 200 cases, while Böhler [3] has analyzed 400 cases.

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Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn., Dec. 5, 1946, by invitation. The paper was read by Dr. Dana M. Street, Chief of Orthopedic Surgery Section, Kennedy Veterans Administration Hospital.

1. Küntscher, G.: Zentralbl. f. Chir. **67**:1145 (June) 1940.

2. Maatz, R., and Reich, H.: Beitr. z. klin. Chir. **174**:358-386 (May) 1943.

3. Böhler, L.: Treatment of Fractures in Peace and in War, ed. 8, Vienna, Wilhelm Maudrich, 1942.

In his early cases Küntscher inserted the nail retrograde into the marrow cavity of the proximal fragment by means of an open reduction. The nail was driven proximally through the canal and out through the greater trochanter of the femur until the distal end was at the fracture site. He then reduced the fracture and drove the nail on down the medullary canal of the distal fragment. In later cases he found that the nail could be inserted directly through the trochanter, the fragments brought into alinement under the fluoroscope and the nail then driven into the distal fragment without resorting to open reduction.

There have been several modifications in the technic and the various devices used to facilitate the introduction or extraction of the nail. The widening of the canal in the distal and proximal thirds of a bone allows a certain degree of lateral displacement in fractures in these locations. Maatz [4] has overcome this by using a double nail consisting of two half-round, trough-shaped nails. These are inserted through a window in the cortex, usually in the lateral wall. The distal or proximal ends of the nails, as the case requires, are made to diverge to keep them in close apposition to the inner surface of the cortex. Herzog [5] has produced a lever device to aid in the closed reduction of the fracture. Stör [6] described a special tool for use in extracting the nail.

Although Küntscher's method has been much used in Europe, there has been, owing to the war, little knowledge of it on this continent, and its advantages are still not widely recognized. We wish to present in this paper 4 cases in which we inserted a medullary nail and which, we believe, well illustrate the indications for its use.

In these cases we have used nails of a somewhat different pattern from the original Küntscher nails (fig. 1). These, designed by one of us (H. H.), are diamond shaped in cross section rather than V shaped. The metal composing them is chrome-nickel stainless steel of the following composition:

Chromium	17.0
Nickel	7.0
Manganese	2.5-0.2
Silicon	1.5-0.2
Copper	0.5
Phosphorus	0.4
Carbon	0.12

REPORT OF CASES

Case 1.—C. E., a white man aged 25, was injured while signaling to make a left turn. He was admitted to the hospital on Sept. 15, 1945, with a comminuted fracture of the left humeral shaft, compound badly comminuted elbow and com-

4. Maatz, R.: Zentralbl. f. Chir. **70**:1641-1649 (Nov. 13) 1943.
5. Herzog, K.: Zentralbl. f. Chir. **70**:1656 (Nov. 13) 1943.
6. Stör, O.: Zentralbl. f. Chir. **70**:754 (May 22) 1943.

Fig. 1.—Medullary nails with diamond cross section—larger for femur and smaller for humerus.

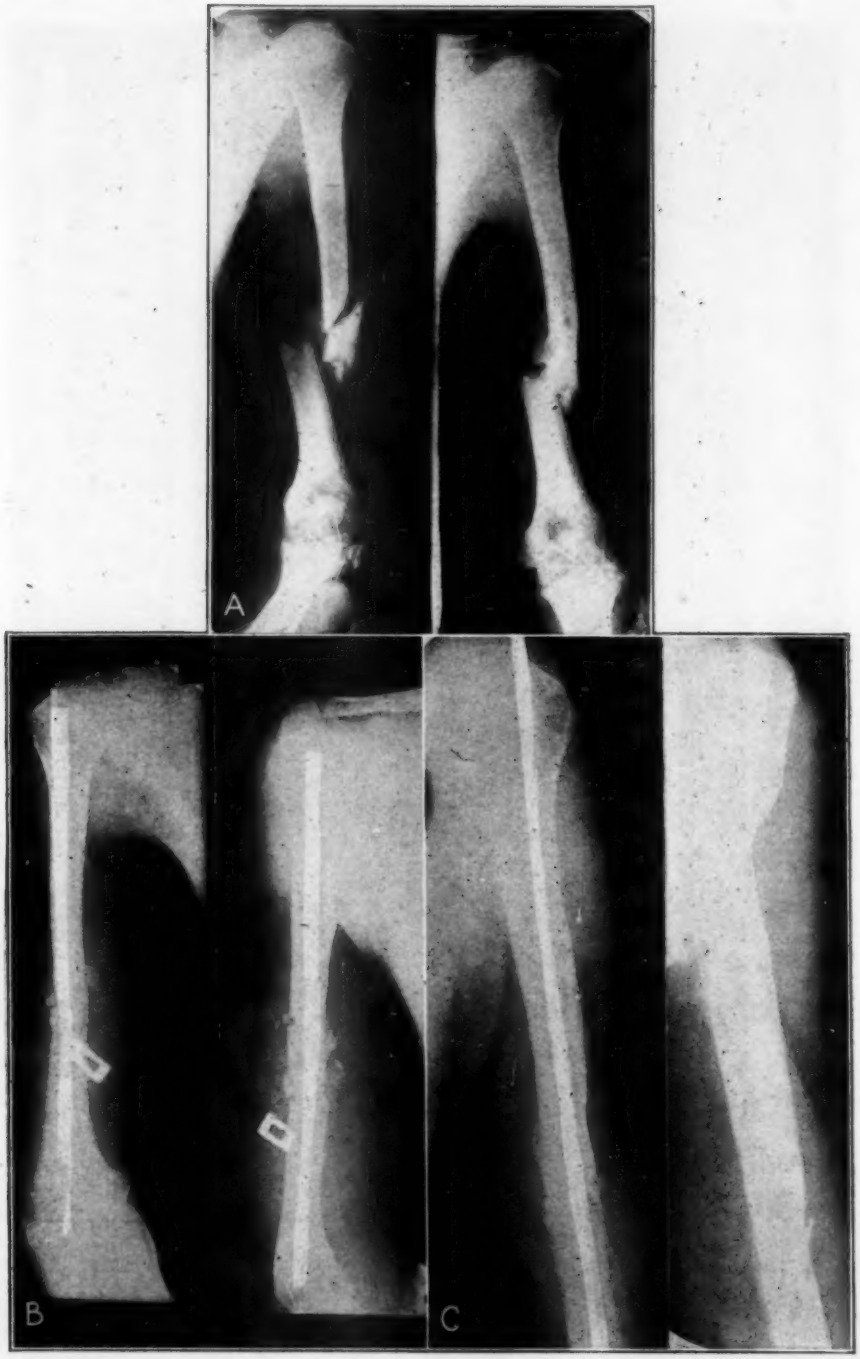

Fig. 2 (case 1).—*A*, fracture six weeks old, prior to operation. *B*, appearance following insertion of medullary nail. *C*, solid union fourteen weeks after operation

pound comminuted fracture of both bones of the forearm. The compound fractures were debrided, and a plate was applied to the ulna, the olecranon wired and a hanging cast applied. At the end of six weeks, the position of the fractured humerus was still unsatisfactory and union was slow; we were anxious to mobilize the elbow (fig. 2*A*). An open reduction was therefore performed, and a nail was inserted through the greater tubercle of the humerus extending down in the medullary canal to within 1.25 inches (3 cm.) from the elbow joint. Fixation was solid in regard to both lateral displacement and rotation, obviating the use of a cast. The postoperative roentgenogram (fig. 2 *B*) shows the reduction maintained by the nail. After fourteen weeks (fig. 2*C*) the fracture lines appeared solid and ready for extraction of the nail.

CASE 2.—H. I., a white youth aged 19, fractured his patella and had an open reduction. Three months later he was in an automobile accident, sustaining a compound refracture of the patella and in addition a fracture of the femoral shaft (fig. 3*A*). He was admitted to the hospital on Dec. 7, 1945, the day of the second injury. The wound was debrided, the distal fragment of the patella excised, the ligaments sutured and skeletal traction applied to the distal end of the femur. Even after two weeks the fractured femur was still so painful that he could not be persuaded to do quadriceps setting or to move his knee at all. An open reduction was then performed and a nail inserted from the greater trochanter to within 3 inches (7.6 cm.) from the knee joint. Fixation was extremely solid, and no cast was necessary. Motion of the knee was begun the day after operation and was quickly restored, with no pain in the thigh. He was allowed up in a wheel chair in two weeks, partial weight bearing with crutches in three weeks and full weight bearing in five weeks. Abundant callus was already present after three weeks (fig. 3*B*) and solid healing after seventeen weeks (fig. 3*C*). The nail could have been withdrawn, but since there were no symptoms it was decided to leave it in for another two or three months.

CASE 3.—D. H., a white man aged 28, was admitted from another hospital on Nov. 23, 1945, six weeks after an airplane crash. In this he sustained a compound transverse fracture of one femur and a simple comminuted fracture of the other. In the latter there were multiple transverse fracture lines forming two intermediate fragments resembling sections of pipe and measuring 3 and 5 inches (7.6 and 12.7 cm.) in length. The position in skeletal traction was unsatisfactory (fig. 4*A*). The compound femur was treated by plating, and when the patient's condition permitted, a nail was threaded down the comminuted femur. A cast was applied because the distal fragment was too short to be securely held by the nail. A composite picture (fig. 4*B*) shows the position of the entire femur postoperatively. Diffuse, poorly calcified callus was visible at twelve weeks with the cast removed (fig. 4*C*).

CASE 4.—H. Y., a white man aged 23, was admitted to the hospital on Jan. 5, 1946, with a simple fracture of the middle third of the right femur (fig. 5*A*). Open reduction was performed because of unsatisfactory position in traction, and a medullary nail was inserted. The patient was allowed to bend his knee immediately after operation and maintained good motion and musculature. He was up in a wheel chair in two weeks and was bearing partial weight in three weeks and full weight in five weeks. Good callus was present at three weeks (fig. 5*B*). The nail was removed after fifteen weeks because of dull pain in the knee, with immediate relief. Full weight bearing without support was continued after removal of the nail. Figure 5*C* shows the massive new bone present at eight months.

Fig. 3 (case 2).—*A*, before operation. *B*, good callus after three weeks. *C*, solid union after seventeen weeks.

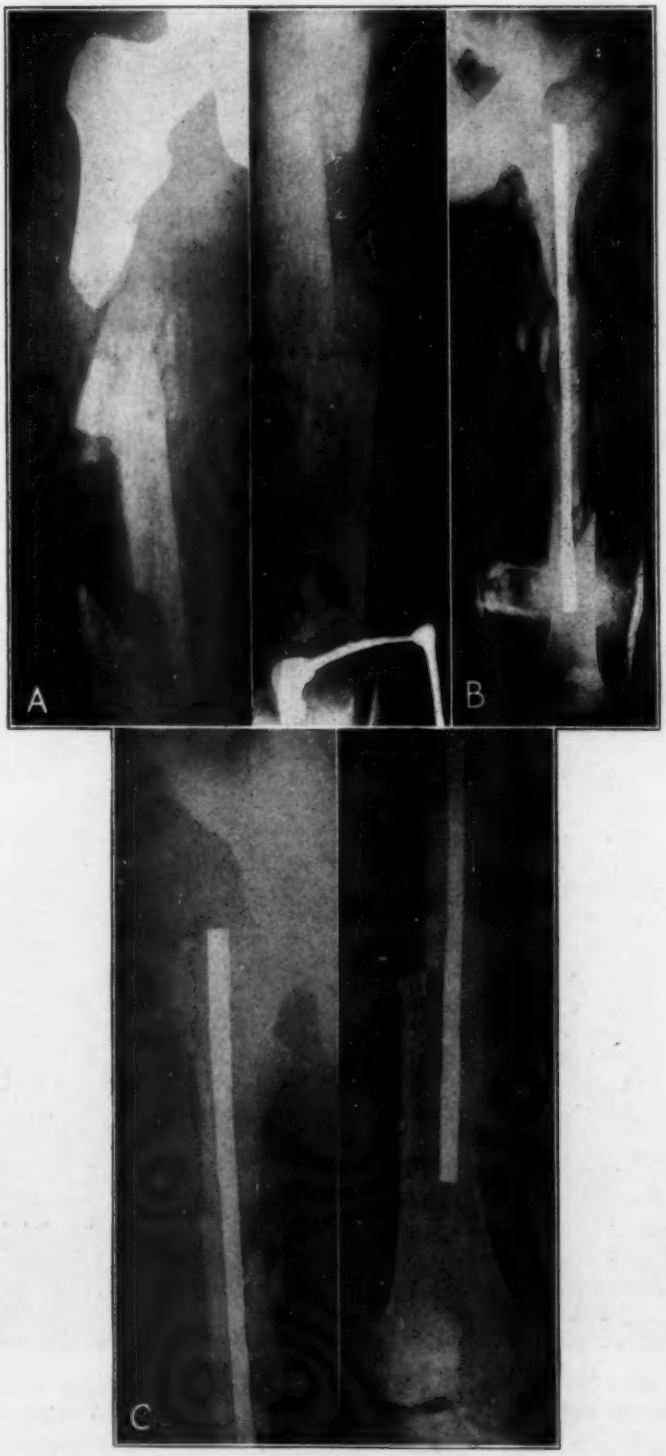

Fig. 4 (case 3).—*A*, preoperative appearance of the fracture. *B*, composite view to show entire length of femur after insertion of nail. *C*, poor callus after twelve weeks.

Fig. 5 (case 4).—*A*, preoperative appearance. *B*, good callus after three weeks. *C*, solid union eight months after insertion of nail and four months after its removal.

COMMENT

Indications for Use of the Method.—These cases, although few in number, clearly show the validity of the advantages originally claimed by Küntscher. The fixation is solid, and no cast is necessary (if the fracture is in the middle third of the femur or middle half of the humerus). Motion of the adjacent joints can be started immediately after insertion of the nail. For this reason, motion need not be restored because it is not lost, and muscles do not require rehabilitation because atrophy does not occur. The patient can be out of bed in two weeks and can be bearing partial weight in three weeks and full weight in six weeks in the average case. The lengthy periods of hospitalization so frequent in fractures of the femur are therefore unnecessary, and elderly patients become ambulatory before onset of hypostatic pneumonia.

This method is particularly suited to the treatment of comminuted fractures in which there are multiple transverse fracture lines, the fragments being threaded on the nail-like beads. Rotation and torque stress are controlled by the nail, and apposition is maintained by muscle tone. The technic is simpler than multiple plates or a single long plate, since these involve many drill holes and the insertion of a dozen or more screws.

The method is not indicated for fractures near the end of a bone. The increased diameter of the medullary canal in such fractures allows lateral displacement, and the short fragment has insufficient hold on the nail. We feel that the method is also contraindicated in compound fractures because of the extensive potential field of contamination. However, this will have to be determined by experience over a period of years.

In 3 of these cases (1, 2 and 3) the callus formation was apparent as early as and in amount equal to that in closed reductions. (Case 3 presents different problems which will be discussed separately.) The callus was not delayed in a manner frequently seen with plate fixation, and no absorption was noted such as is seen in methods of pin fixation. This we attributed, as did Küntscher, to the anatomic apposition rigidly maintained by control of torque and displacement and also to the physiologic pressure between the ends of the bone exerted by the normal pull of the muscles. The method, therefore, instead of being nonphysiologic as it might at first appear, may in reality be the most physiologic of any method of skeletal fixation as yet devised.

In case 3 the callus was considerably less abundant. There are several factors which may account for this. The operation was performed eight weeks after injury, or after the time when the maximum formation of callus normally occurs. Callus was found to be scant at the time of operation. There was an associated fracture of a large bone

other than the one nailed. The fragments were segmental in nature. The relative importance of these factors is not within the scope of this discussion.

Technic.—In the cases presented, open reductions were performed for two reasons. First, accurate reduction was insured. Second, we considered that there was risk of fat embolism in the closed method. A nail measuring 45 cm. in length and 20 sq. mm. in cross section displaces about 2 teaspoons of fatty marrow. This must be extruded at the fracture site. We consider this pool of fat a real potential danger and prefer to wash it out with ether.

It has been our experience that the retrograde method of inserting the nail through the proximal fragment is technically simpler than inserting it directly through the greater trochanter of the femur.

Type of Nail.—The modification of Dr. Maatz, while theoretically good, requires that two nails be especially constructed for each case; also a window is necessary in the side of the shaft. The diamond-shaped nail which we have used differs from the Küntscher nail in that it spans the diameter of the canal rather than three chords. It provides extremely rigid fixation, while at the same time it contacts the inner surface (as viewed in cross section) at only two points instead of three. It therefore leaves more of the surface of the canal unmolested.

The choice of metal is of course important. It must not bend under the force of the adductors plus adduction stress of weight bearing since removal of a bent nail is difficult. It must be resilient but not brittle since a broken nail would also present a problem in its removal. It must also be as nearly isoelectric as possible. We chose stainless steel as the metal best suiting these requirements. The two nails thus far removed still showed a high polish. Although the pain in the last patient was attributed to reaction about the nail, it was still snug and required driving with a mallet to remove it.

SUMMARY

Treatment of fractures of the shaft of long bones by means of a medullary nail was introduced by Küntscher in 1940 and has since been extensively used in Europe. Its use is indicated for simple fractures in the middle third of the femur or middle half of the humerus (*a*) with multiple segmental fragments, (*b*) with associated fracture into the adjacent knee or elbow joint and (*c*) in elderly persons.

Open reduction is preferred to closed reduction because of danger from fat embolism.

A new type of nail is presented (diamond shaped).

SURGICAL RELIEF OF PAIN IN PARAPLEGIC PATIENTS

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FROM the recent worldwide conflict approximately 2,000 persons returned to this country with severe injuries to the spinal cord and spinal nerves. Of these, some 600 have been under our care for varying periods. Recent years have brought the wholesale discard of older concepts of paraplegic care, and the life expectancy of the average patient with severe injury of the spinal cord has been lengthened from about eighteen months to perhaps a normal one. In consequence of the renewed hope for this type of patient, the administration of drugs which produce addiction for the relief of pain can no longer be countenanced. It is our firm belief that pain can kill, if not outright as in a case recorded by Tinsley,[1] then at least insidiously through its continued action in bringing about starvation. For the purpose of simplification, pain in the paraplegic patient can be classified into three types. Usually more than one of these elements will be present in the individual case.

CLASSIFICATION

1. *Somatic Pain.*—Somatic pain is that pain characterized by intermittency, sharpness and conformation to dermatome patterns. It is found most frequently in patients with injury to the cauda equina and affects the dermatomes in which no sensation is present. Thus it can be likened to a phantom pain. In some instances the hyperalgesia of the segments lying directly above the site of injury may amount to actual pain.

2. *Sympathetic Pain.*—Sympathetic pain is characterized by its constancy, by its dull, aching or burning nature and by its vague reference to such regions as the back of the leg. This includes the so-called visceral pain.

3. *Psychic Pain.*—Psychic pain has no definite characterizing features and does not lend itself to definition. In the philosophic sense, one

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn., Dec. 5, 1946.

From the Paraplegia Section of the Surgical Service, Kennedy Veterans' Administration Hospital, Memphis, Tenn.

1. Tinsley, M.: Compound Injuries of the Spinal Cord, J. Neurosurg. **3**: 306-309 (July) 1946.

might find the description of pain as the absence of pleasurable sensations (Schopenhauer) more elucidating than the many vague terms of modern psychology. Because these patients have suffered severe mental trauma, it is necessary to speak of the diagnosis of pain.

DIAGNOSIS OF PAIN

In figure 1 is shown a patient who suffered a gunshot wound of his abdomen in combat. The missile perforated his large bowel and the lower spinal canal, producing severe damage to the cauda equina. At the time this photograph was taken, nineteen months had elapsed since injury and the use of narcotics had been withdrawn over the last three

Fig. 1.—Patient with lesion at the cauda equina suffered in combat nineteen months previously. Somatic pain was the dominant complaint; all types of pain in the legs and trunk were relieved by bilateral cordotomy performed high up.

months. Of special interest are the position and the facies. The drawn expression—"hang-dog" look—and the sharply flexed posture are typical of a patient suffering severe pain. Nutrition is poor despite frequent transfusions, special proteins and numerous efforts to stimulate the appetite. Once this picture of true somatic pain has been seen, the purely "psychic pain" can be recognized quickly. With this type it is observed that only as the physician approaches the bedside is the patient stirred from cheerful conversation with his bedfellows. His appeals for relief of pain know no bounds, except that surgical relief is usually resisted. On adoption of the policy that pain requiring

morphine for relief should be attacked surgically, many of the pseudopains cease to be problems. The patient suffering somatic pain can give a clear description of all aspects of it. Sympathetic pain does not lend itself to such accurate description, but the story fits the pattern of pain of peripheral vascular disease so well that it is also relatively clear. However, the sufferer from pseudopain finds it necessary to use verbiage far beyond the standard of his educational achievements. Long, drawn-out, vague descriptions, evasions of direct questions and the profound lability of emotions will serve to arouse suspicion. Far greater difficulty is encountered in cases which demonstrate combinations of all the types discussed. Several test methods may be used:

(*a*) Placebo therapy. When the psychic component must be considered as a large contributor, a course of placebo therapy will often be of considerable benefit. In highly emotional patients the threat of suicide during such a course has been encountered.

(*b*) Sympathetic nerve block. This should temporarily relieve the sympathetic type of pain. However, since the origin of the pain is probably not peripheral, care should be exercised in evaluating therapy suggested by this procedure.

(*c*) Procaine hydrochloride anesthesia of "trigger points." This should be used in all cases in which these can be demonstrated.

(*d*) Caudal or extradural procaine hydrochloride anesthesia. This will temporarily relieve somatic pain but often will not influence psychic pain.

(*e*) Controlled spinal anesthesia. This procedure, described by Fay and Gotten,[2] has been used in a modified fashion to demonstrate the likelihood of success of intraspinal procedures.

Each of these test methods may give permanent benefits, especially if they are repeated.

SURGICAL PROCEDURES FOR RELIEF

Surgical procedures for relief include the following:

1. Injection of alcohol into peripheral nerves. This procedure has extremely limited application but can be used with temporary success when previous injection with procaine hydrochloride has given relief.

2. Injection of alcohol in the epidural space. This procedure has limited use in the paraplegic patient because of the scarring of the dura at the site of injury.

3. Injection of alcohol in the subarachnoid space (Dogliotti[3]). From 1 to 2 cc. of absolute alcohol is injected slowly in the subarachnoid space

2. Fay, T., and Gotten, N.: Controlled Spinal Anesthesia: Its Value in Establishing Appropriate Levels for Chordotomy, Arch. Neurol. & Psychiat. **30**: 1276-1281 (Dec.) 1933.

3. Dogliotti, A. M.: Traitement des syndromes douloureaux de la périphérie par l' alcoolisation sub-arachnoïdienne des racines postérieurs à leur émergence de la moelle épinierè, Presse méd. **39**:1249-1252 (Aug. 22) 1931.

with the patient lying on the unaffected side, arched at the point at which maximum effect is desired and turned slightly to the back to keep the posterior roots uppermost.

4. Sympathectomy. Routine lumbar sympathectomy or the Peet,[4] Adson [5] or Smithwick [6] procedures can be utilized. Results in 5 cases have been disappointing enough to warrant hesitation in the utilization of this procedure.

5. Decompressive laminectomy, leaving the dura open. This has less success in late cases than it does in early ones.

6. Dorsal rhizotomy. An occasional case will be found in which section of appropriate spinal posterior roots would seem to be indicated. However, success is limited.

7. Chordotomy. Section of the anterolateral spinothalamic tracts will be found to be necessary in most cases.

STATISTICS

Analyses of cases at various centers have given data which show large differences in the proportion suffering with pain. At one center only 12 per cent of the patients required special attention to pain. At another the figure jumped to 17 per cent. Astoundingly enough, at a third the indications were that over 50 per cent had problematic pain. Reevaluation of this last group soon showed that careful diagnosis, assurance, occupation and placebo therapy reduced this proportion to approximately 15 per cent. Few patients with lesions above the cauda equina have real pain. Careful analysis will reveal that unpleasant sensations are interpreted as pain, and custom causes these patients to request hypodermic injections for relief. However, there remains a large number of patients, almost all of them with lesions of the cauda equina, who face addiction to drugs unless surgical relief is offered. No attempt is made to include the rather numerous acute pains occurring in the course of common ailments.

In the accompanying table the results of the surgical procedures are briefly summarized. In some patients more than one procedure was carried out before relief was obtained. Not all the 600 patients had been under our care for sufficient time to determine the necessity for surgical relief of pain. However, approximately two thirds of them had been under our care for a period of more than six months.

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4. Peet, M. M.; Woods, W. W., and Braden, S.: The Surgical Treatment of Hypertension: Results in Three Hundred and Fifty Consecutive Cases Treated by Bilateral Subdiaphragmatic Splanchnicectomy and Lower Dorsal Ganglionectomy, J. A. M. A. **115**:1875-188 (Nov. 30) 1940.

5. Adson, A. W., and Brown, G. E.: Treatment of Raynaud's Disease by Lumbar Ramisection and Ganglionectomy and Perivascular Sympathetic Neurectomy of the Common Iliacs, J. A. M. A. **84**:1908-1910 (June 20) 1925.

6. Smithwick, R.: Surgical Intervention on the Sympathetic Nervous System for Peripheral Vascular Disease, Arch. Surg. **40**:286-306 (Feb.) 1940.

COMMENT

The failure of any surgical procedure short of chordotomy can be predicted with relative certainty. All paraplegic patients have suffered injury to the contents of the spinal canal, and efforts aimed at the periphery disregard the seat of the pathologic changes. The failure of dorsal rhizotomy comes from the fact that only the projection site is removed, whereas the pathologic phenomena are present at or in the spinal cord. Sympathectomy is likewise doomed to failure since the typical pain is often present in patients showing complete sympathectomy effect in the lower limbs. In the arms, success of sympathectomy can be predicted in cases in which the injury included the brachial plexus. Emphasis for the view that sympathectomy will usually fail is provided by the observation that patients with complete transections at or above the third dorsal dermatome do not complain of pain in the legs or viscera.

Results of Surgical Procedures in Cases of Paraplegia

Procedure	Number of Cases	Pain Abolished	Pain Improved	Pain Unchanged at Six Weeks	Comment
Decompressive laminectomy	5	0	0	5	Does not include cases in which the operation was done soon after injury
Dorsal rhizotomy	3	0	3	0	Somatic pain was abolished but sympathetic pain remained
Sympathectomy	5	0	2	3	Two improved patients had lumbodorsal (D10-L2) sympathectomy
Chordotomy	45	34	9	2	See text: 6 patients were operated on twice

Two exceptions to this statement must be recorded. Figure 2 shows photomicrographs taken of a 2.3 cm. piece of spinal cord between the second and third thoracic roots removed from a patient who had suffered a clinically complete lesion twenty months prior to operation. His sensory level was the fourth thoracic dermatome, and he complained bitterly of pain in the right leg. Numerous gitter cells and inflammatory signs are seen. No normal structure can be distinguished. Postoperatively, there was little diminution of pain until thiamine, nicotinic acid and finally histamine desensitization were used. In a second case there were gross findings of considerable inflammatory changes at the second thoracic dermatome, without relief of pain in the trunk despite section of the anterior half of the cord. These cases are presented as instances of spinothalamic tractitis.

Patients with lesions at any lower point may complain of burning pain, more severe the lower the lesion and most severe when the cauda equina is involved. Section of the lateral spinothalamic tracts below the second dorsal dermatome has failed in most instances to abolish the sympathetic type of pain. Section of these tracts between

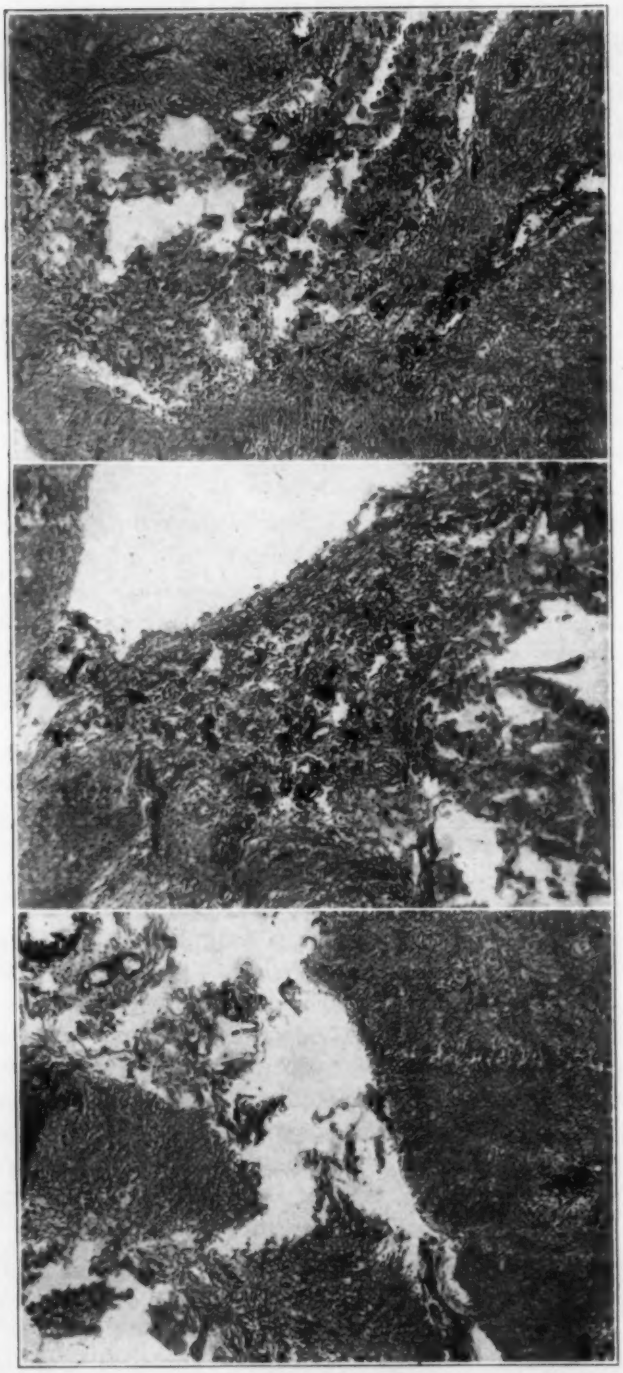

Fig. 2.—Photomicrographs of a segment of spinal cord from between the second and third thoracic roots in a patient with complete paraplegia suffered twenty months prior to operation. Pain was present in the right leg from the time of injury and was not relieved by the operation.

the first and second dorsal roots has uniformly abolished all types of pain in the legs or viscera. Consequently, it is felt that the surgical procedure of choice for relief of pain in the majority of patients is bilateral chordotomy between the first and second dorsal roots.

Of the 45 patients undergoing chordotomy listed in the table, 24 were operated on by us. In 6 of these it was done twice because there was failure to relieve the pain and inadequate levels of analgesia were demonstrable after the first procedure. The 2 patients listed as not improved after six weeks had no change in their levels of analgesia postoperatively. Each of the patients with only partial relief had inadequate levels of analgesia on at least one side.

All patients in whom the level of analgesia reached above the dermatome level of the referred pain had complete relief of somatic pain. All patients with levels of analgesia at or above the third dorsal dermatome had complete relief of somatic and sympathetic pain.

Differential chordotomy was done in 4 patients centered at the sixth dorsal vertebra. Each of these obtained temporary relief only. Unilateral chordotomy was done in 12 cases, but this served only to unmask the pain in the other leg, and the other side had to be sectioned. We have been gradually performing chordotomies higher in the spinal canal, until we now do them between the first and second thoracic roots in all cases. This has been necessary, since early operations which gave levels of analgesia at any point below the fourth thoracic dermatome only relieved the somatic pain and often did not relieve the sympathetic pain. Fortunately, a large percentage of the earlier patients subjected to chordotomy either did not have sympathetic pain or were able to tolerate it. The postoperative discomfort from the procedure as carried out higher up is much less, and the execution is no more difficult. No operative deaths occurred in this group.

Local anesthesia is preferred, since the adequacy of the procedure can be assured on the operating table by sensory examination. In patients who do not permit the use of local anesthesia failure to produce adequate levels of analgesia has required that the operation be repeated. This is usually done on the tenth day after the first procedure.

Complications encountered include involvement of the bladder and spasticity. No permanent involvement of the bladder has been produced. However, several patients lost pain as an index of fulness of the bladder after the procedure. Of the 45 patients listed, 7 had some degree of postoperative spasticity, but none had permanent loss of motion present preoperatively. In only 1 case was this spasticity of any concern.

The surgical technic used by us follows the pattern laid down by Frazier [7] and elaborated by others.[8] Figure 3 (drawn by one of the

7. Frazier, C. H.: Section of the Anterolateral Columns of the Spinal Cord for Relief of Pain: A Report of Six Cases, Arch. Neurol. & Psychiat. 4:137-147 (Aug.) 1920.

(Footnotes continued on next page)

patients) shows the ideal course of the knife in chordotomy. Although the section must closely approach the gray matter, we do not feel that, as in the dog,[9] there is any necessity of entering it. This view is substantiated by Hyndman.[8b] We have used successively deeper and more anterior sections in almost all our cases and find that as the section is continued medially and anteriorly the level is raised. We have made no observations of the temperatures. In the region between the first and second thoracic roots a depth of 5 mm. must be reached, and the tip of the knife must emerge at least 2 mm. anterior to the point of emergence of the anterior root to insure adequate levels of analgesia and relief of pain. Unfortunately, the severe degree of paralysis already present in almost all cases does not permit accurate observation of the loss of motor function. In bilateral sections the incisions should be placed at least 1 cm. apart to prevent the production of a complete transection.

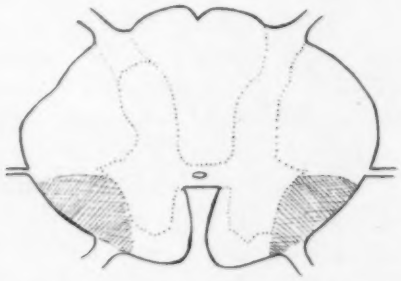

Fig. 3.—Diagrammatic sketch of spinal cord to show approximate course of the knife in cordotomy. This is a 13 mm. cross section at D2.

SUMMARY

Bilateral chordotomy performed high up, below the arm area, is presented as the best answer to the problem of somatic and sympathetic pain in the trunk and lower limbs of patients with injury of the spinal cord.

Diagnostic procedures for differentiation of the types of pain are listed. Caution in the analysis of pain is urged. The central origin of the pain is emphasized.

8. (*a*) Kahn, E. A.: Anterolateral Chordotomy for Intractable Pain, J. A. M. A. **100**:1925-1928 (June 17) 1933. (*b*) Hyndman, O. R., and Van Epps, C.: Possibility of Differential Section of the Spinothalamic Tract: A Clinical and Histologic Study, Arch. Surg. **38**:1036-1053 (June) 1939.

9. Davis, L.; Hart, J. T., and Crain, R. C.: The Pathway for Visceral Afferent Impulses Within the Spinal Cord: II. Experimental Dilatation of the Biliary Ducts, Surg., Gynec. & Obst. **48**:647-651 (May) 1929.

FOREIGN BODIES IN THE INTESTINAL TRACT

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THE TOOTHPICK is still widely used in America. It accompanies the Martini, the Manhattan, the Old-Fashioned, the canapé and the club sandwich. The integrity of the last popular item with its many unstable layers requires the holding power of the toothpick. One equipped with artificial dentures may not have to use the toothpick as such, but with the loss of sensory stimuli in the roof of the mouth and the gums it is much easier to ingest unknowingly a foreign body in a morsel of food. Cocktails, canapés and club sandwiches are conducive to the careless handling of toothpicks, and that more are not arrested somewhere along the intestinal tract is due only to the marvelous mechanism in the intestinal tube which makes it possible to manage foreign bodies in great quantity without serious damage. This mechanism was described by Carp [1] in 1927. He described the experimental work of Exner, showing that large quantities of sharp foreign bodies, such as spicules of glass and needles, can be introduced into the stomach of dogs and cats, and the intestinal tract can turn and expel them, blunt end first, within twenty-four hours without injury to the intestinal mucosa. Carp [1] further described the points of arrest as (*a*) the junction of the second and the third part of the duodenum, (*b*) the ileocecal region, (*c*) the lumen of the appendix, (*d*) the junction of the cecum and the ascending colon and (*e*) the flexures and haustra of the large intestine.

Carp [1] reported a series of 48 proved cases of foreign bodies in the intestine occurring in the Presbyterian Hospital in New York between 1915 and 1926, all the bodies having been swallowed and many different types encountered. In most of them in which the patient could be followed the body was evacuated without untoward symptoms. Of the 31 cases with follow-up observation, the body was passed in 25, or 80 per cent.

From the Pember Nuzum Clinic.

Read at the Fifty-Fourth Annual Meeting of the Western Surgical Association, Memphis, Tenn., Dec. 7, 1946.

1. Carp, L.: Foreign Bodies in the Intestines, Ann. Surg. **85**:575-591 (April) 1927.

That foreign bodies are arrested in the intestinal tract and do cause serious damage is attested by the numerous reports from the literature. However, cases in which the toothpick is the cause of the trouble are comparatively few. While most foreign bodies are swallowed accidentally, it is not infrequent practice among the insane and certain professional persons to make a business of eating glass and other objects.

Cannady,[2] in 1931, in a discussion of this subject, reported the case of a woman aged 26 who was operated on three times within a year. Each time a large number of foreign bodies were removed, and the last time 140 such objects, mostly wire nails, screws, and the like, were removed from the stomach. In his conclusions, he stated that "while there have been several reported cases of perforation of the cecum by wooden toothpicks, perforation of the viscus by nails or other pointed metal objects is a comparatively rare occurrence."

While the present discussion applies to foreign bodies in general, the case reports are limited to those of toothpicks and similar slivers of wood. Although chewing toothpicks is a common practice, I have found no case in which a person made a business of eating toothpicks, and in only 1 case did the victim recall the time at which the object was swallowed.

In 1926, Ginzburg and Beller[3] reported 12 cases of nonmetallic foreign bodies in the intestinal tract: 6 of fishbones, 5 of chicken bones and 1 of a toothpick. They found the cecum and the flexures of the colon the most common sites of arrest; and the conditions most frequently noted were (*a*) acute peritonitis, (*b*) localized intestinal abscess, (*c*) intra-abdominal inflammatory tumor, (*d*) inflammatory tumor of the abdominal wall, (*e*) abscess of the abdominal wall and (*f*) inflammation and obstruction in a hernial sac.

MacManus,[4] in 1941, collected 95 cases from the literature, excluding cases of perforation by ingested blunt foreign bodies. Of these, toothpicks and splinters of wood caused perforation in 9 cases, or in more than 9 per cent of the whole series. He found the predominance of perforations in the lower iliac and the cecal region. Aside from a large number which occurred in the appendix and in Meckel's diverticulum, the perforations in 20 of the 95 cases were in these regions. In 50 per cent of the cases the duration of symptoms ranged from a few hours to two weeks. The mortality rate in the surgical period before 1900 was 53.5

2. Cannady, J. E.: Foreign Bodies in the Stomach and Intestines, Ann. Surg. **94**:218-232 (Aug.) 1931.

3. Ginzburg, L., and Beller, A. J.: The Clinical Manifestations of Nonmetallic Perforating Intestinal Foreign Bodies, Ann. Surg. **86**:928-939 (Dec.) 1926.

4. MacManus, J. E.: Perforations of the Intestine by Ingested Foreign Bodies, Am. J. Surg. **53**:393-402 (Sept.) 1941.

per cent, and in the period after 1900 it dropped to 10 per cent. MacManus [4] also reported a case of his own in which a toothpick was the cause of the perforation.

Melville,[5] in 1940, in discussing perforation of the intestinal tract by foreign bodies, stated that the condition is not common and apparently has never been diagnosed before operation or autopsy, because of the close similarity to acute appendicitis in most cases. In others, the clinical features have been too confusing to suggest the origin of the peritonitis. The confusion in the latter group may be due to the rarity of similar cases in any one surgeon's experience. To aid in the diagnosis of the condition, Melville postulated a theoretic complex consisting of (*a*) colic, (*b*) peritonitis and (*c*) a lower abdominal locus, and expressed the belief that many acute cases do approximate this concept.

In a review of the literature, I have collected 20 cases in which a toothpick was the source of the trouble and have added 1 case of my own. In 13 of these cases the trouble was diagnosed as acute appendicitis and in 2 as abscess of the abdominal wall. In 1 case the diagnosis was peritonitis, and in 4 it was not determined before operation.

The site of perforation in 10 cases was the cecum; in 3 cases, Meckel's diverticulum, and in 2 cases, the duodenum. In 1 case the toothpick was found free in the peritoneal cavity close to the duodenum, and in a case reported by Rivers and Davison [6] the point of the toothpick was in a duodenal ulcer 6 cm. below the pylorus and the other end projected into the stomach. In 2 cases the perforation was in the ileum, and in a case reported by Maxeiner,[7] of this society, the toothpick was observed penetrating a diverticulum of the sigmoid and had caused a pelvic abscess. In 1 case the toothpick had penetrated the transverse colon, and in another, the small intestine and abdominal wall.

In 10 cases an abscess was present. In 9 cases there was evidence of considerable inflammation but no abscess, and in 1 case the presence of abscess was not mentioned.

In 13 cases the source of the foreign body was unknown. In a case reported by Vestal,[8] a child aged 9 had swallowed a toothpick while drinking a glass of water nine days previously. She did not tell her parents of this seemingly difficult feat. Wallis [9] reported a case in which

5. Melville, C. B.: Perforation of Small Intestine by Swallowed Foreign Bodies, Australian & New Zealand J. Surg. **10**:146-156 (Oct.) 1940.

6. Rivers, A. B., and Davison, H. L.: Foreign Bodies in the Stomach, Ann. Int. Med. **4**:742-751 (Jan.) 1931.

7. Eitel, G. D.: Ingested Foreign Bodies in the Gastro-Intestinal Tract Requiring Surgical Removal, Minnesota Med. **18**:52-59 (Jan.) 1935.

8. Vestal, P. W.: Perforation of Cecum by Foreign Bodies, with a Report of a Case Simulating Appendicitis, New England J. Med. **203**:1199-1200 (Dec. 11) 1930.

9. Wallis, T. B.: Perforation of the Cecum by a Toothpick: Case Report, J. Florida M. A. **17**:127-129 (Sept.) 1930.

a man was in the habit of using toothpicks after a meal and then falling asleep with the toothpick in his mouth. His wife usually removed it, but if not he would awaken with the toothpick still in his mouth. Wallis [9] further stated, "Let me caution you: If you are a toothpick user, be sure that your wife is faithful in her duty, or tie a string to your toothpick when it is not in use." This is probably the answer to the safety toothpick. McClintic [10] said that his patient worked at odd times in a restaurant and was in the habit of hurriedly eating three decker sandwiches held together with toothpicks. Henderson and Gaston [11] reported a case in which the man identified the splinter of wood as being a part of the seasoning used in cooking the spaghetti which he had eaten six hours before the beginning of his symptoms. Zieman [12] stated that his patient ate veal birds pinned together with toothpicks and wore upper and lower dentures, suggesting the possibility of eating the toothpick without feeling it in his mouth. In 1 case a "hot dog" pinned together with toothpicks was to blame. Evans and Hanlon [13] concluded that the habit of chewing toothpicks is not only inelegant but dangerous.

All the 20 patients recovered. One author noted that the patient had a stormy convalescence. Three cases were of children and 17 of adults. The perforating object was identified as a toothpick in 17 cases and as wood splinters, similar in size and shape, in 3 cases. The present report adds a case to this small group.

REPORT OF A CASE

A man, aged 51 registered at the clinic on June 20, 1945, for repair of an incisional hernia which had been diagnosed elsewhere. He gave no history of previous illness. Shortly after Thanksgiving Day in 1944 he experienced sharp abdominal pain. Several days later he entered a hospital elsewhere and was observed for four days before operation. A diagnosis of acute appendicitis was made. Exploration was done through a right rectus incision and the appendix removed. He was in the hospital a little over two weeks and soon after the operation was fitted with a girdle, which he had worn since. Later a bulging and bunch were discovered in the wound, and he felt that the incision did not look right. He gained weight after the operation, reaching 220 pounds (99.8 Kg.), but with diet and medication he reduced his weight to 179 pounds (81.2 Kg), and at the time of his examination at the clinic he weighed 190 pounds (86.2 Kg.). He also described a sharp, penetrating pain and a sensation of tearing in the scar. He had no nausea or vomiting. He stated that several weeks before entering the hospital the second

10. McClintic, B. S.: Perforation of Intestines by Foreign Bodies, Mil. Surgeon **75**:75-78 (Aug.) 1934.

11. Henderson, F. F., and Gaston, E. A.: Ingested Foreign Body in the Gastrointestinal Tract, Arch. Surg. **36**:66-95 (Jan.) 1938.

12. Zieman, S. A.: Perforating Foreign Body of Cecum, U. S. Nav. M. Bull. **43**:1103-1105 (July) 1943.

13. Evans, R. L., and Hanlon, G. D.: Perforation of a Meckel's Diverticulum by a Portion of a Toothpick, Guthrie Clin. Bull. **12**:102-104 (Jan.) 1943.

time he had strained himself in lifting and had much pain in the region of the scar, resembling the pain of appendicitis. He said that it had been necessary for him to take cathartics to keep his bowels moving. Examination revealed a large, healthy-appearing man, about 5 feet 10 inches (178 cm.) in height. He had a complete upper denture; his lower teeth were fairly good. He had a scar on the right shoulder and a recent scar in the lower part of the right rectus muscle, with wide separation of the muscles and some bulging, increased with coughing and straining, in the upper part of the wound. The blood pressure, pulse and temperature were within normal limits. The urine and the blood chemistry were normal. The Wassermann reaction of the blood was negative. The blood counts were normal, showing a leukocyte count of only 7,600 and no change in the differential count. Pain and soreness in the wound were so definite and had been so prolonged that exploration appeared advisable.

Operation was performed on June 23, with the patient under anesthesia induced with cyclopropane, oxygen and ether. The old scar in the right rectus muscle was dissected out through an elliptic incision, and exploration revealed a wide separation of the upper layer of fascia and evidence of a good deal of low grade inflammation. The sac was opened, and many adhesions were encountered between the intestinal coils and the sac. After these adhesions were separated, more adhesions were observed between the loops of the bowel. During the course of the manipulation an object was noted in the bowel which tented it up and almost protruded through it. After further separation of the adhesions, the intestine was opened transversely and an object 2¾ inches (7 cm.) long, in the shape of a toothpick, was removed. This object had perforated posteriorly into the mesentery and worked back and forth in this loop of ileum, possibly perforating the abdominal wall at several points; at least the heavy scar tissue indicated that this might have occurred. The opening of the intestine was closed; additional adhesions were separated; 5 Gm. of sulfanilamide was placed in the peritoneal cavity; the muscle was dissected out, and the wound was closed, using chromic surgical gut sutures in the peritoneum, and interrupted wire sutures in the fascial layers, the suture line being reenforced with continuous fascial strips previously taken from the right thigh and laced back and forth after the method of Gallie. The subcutaneous layer was closed with interrupted cotton sutures and the skin with clips. The patient made a rather rapid and uneventful recovery and was dismissed from the hospital on July 5. When he was seen a month later, he appeared to have an excellent result and was free from symptoms.

How he acquired this troublesome item in his diet he was not certain. He did not use toothpicks in the usual way, for he had artificial dentures. He revealed that he had been accustomed to eat club sandwiches in the past and admitted that it was entirely possible that he may have ingested this toothpick with the sandwich inadvertently, not detecting it because the roof of his mouth was protected with the denture. This explanation seems logical.

COMMENT

It may be said that accidentally ingested foreign bodies generally cause little trouble, but when they do it is usually because they are arrested and perforate at one of the angles of the intestinal tract, the ileocecal region being by far the most common site. The symptoms generally are such that acute appendicitis or appendical abscess is suspected. The most commonly used instrument in the mouth, the wooden

toothpick, appears to be the least common cause of perforation or other complications incident to the presence of a foreign body in the intestinal tract.

The literature has been reviewed and 20 cases collected in which a toothpick, or a splinter of wood similar to a toothpick, was the cause of perforation or other complications in the intestinal tract (table). The data are analyzed in the following tabulation.

Diagnosis	
Acute appendicitis	13
Abscess in the abdominal wall	2
Peritonitis	1
Undetermined	4
	20
Perforation	
Cecum	10
Meckel's diverticulum	3
Duodenum	2
Ileum	2
Diverticulum of the sigmoid	1
Transverse colon	1
Intestine and abdominal wall	1
	20
Abscess	
Present	10
Absent	9
Unstated	1
	20
Source of foreign body	
Unknown	13
Drank in glass of water	1
Fell asleep with toothpick in mouth	1
Three decker sandwich	1
Spaghetti seasoning	1
Veal birds	1
Hot dog	1
Chewing toothpicks	1
	20

SUMMARY OF CASES FROM THE LITERATURE

In 1926 Ginzburg and Beller [3] reported the case (case 4 in their series) of a man aged 40 with a diagnosis of acute appendicitis with abscess. The operation revealed a normal appendix and a retrocolic abscess, with a fragment of toothpick 1 inch (2.5 cm.) long perforating the posterior wall of the upper part of the cecum and lying outside of the lumen. The perforation was closed and drained, and the patient recovered.

In 1930 Durman and Belz [14] reported the case of a woman aged 48 with pain of six months' duration in the left side of the abdomen.

14. Durman, C. D., and Belz, F.: Abscess from Swallowed Toothpick, J. A. M. A. **94**:1830 (June 7) 1930.

Data on Cases in the Literature

Date	Author	Diagnosis	Sex	Age, Yr.	Location	Object	Abscess	Site of Perforation	Source of Foreign Body	Outcome
1926	Ginzburg and Beller [3]	Acute appendicitis with abscess	M	40	Retrocecal	Toothpick	Yes	Cecum	Unknown	Recovery
1930	Durman and Belz [14]	Abscess of abdominal wall	F	48	Left side of abdomen	Toothpick	Yes	Intestine and abdominal wall	Unknown	Recovery
1930	Vestal [8]	Acute appendicitis	F	9	Right lower quadrant	Toothpick	Yes	Cecum	In glass of water	Recovery
1930	Wallis [9]	Acute appendicitis with abscess	M	?	Ileocecal junction	Toothpick	Yes	Cecum	Patient fell asleep with toothpick in mouth	Recovery
1930	McLanahan [15]	Appendicitis	M	44	Cecum	Toothpick	Yes	Cecum	Unknown	Recovery
1931	Rivers and Davison [6]	Undetermined	F	?	Duodenum	Toothpick	?	Duodenal ulcer	Unknown	Recovery
1934	McClintic [10]	Acute appendicitis	M	34	Cecum and appendix	Toothpick	No	Cecum	Three decker sandwich	Recovery
1935	Maxeiner [7]	Pelvic abscess; ruptured appendix	?	?	Pelvis	Toothpick	Yes	Diverticulum of sigmoid	Unknown	Recovery
1937	Donavan [16]	Acute appendicitis	M	11	Meckel's diverticulum	Wood splinter	No	Meckel's diverticulum	Unknown	Recovery
1938	Henderson and Gaston [11]	Mass, right, over Poupart's ligament	M	8	Ileum	Wood splinter	No	Ileum	Unknown	Recovery
1938	Henderson and Gaston [11]	Pain in upper right abdominal quadrant	M	45	Peritoneal cavity near stomach	Wood splinter	No	First part of duodenum	Spaghetti seasoning	Recovery
1940	Melville [5]	Peritonitis, right lower quadrant	F	?	Right iliac fossa	Toothpick	Yes	Ileum, two places	Unknown	Recovery, stormy convalescence
1941	MacManus [4]	Appendicitis	M	65	Cecum, lateral wall	Toothpick	Yes	Cecum	Unknown	Recovery
1942	Barrett and Leader [17]	Appendicitis	M	?	Terminal part of ileum	Toothpick	No	Cecum	Unknown	Recovery
1943	Goehring [18]	Abscess of lower part of abdomen; obstruction of bowel	M	63	Ileum and transverse colon	Toothpick	Yes	Transverse colon, obstructing cecum	Unknown	Recovery
1943	Zieman [12]	Ruptured appendix	?	?	Cecum and lateral wall	Toothpick	Yes	Cecum	Veal birds	Recovery
1943	Evans and Hanlon [13]	Acute appendicitis	M	28	Terminal part of ileum	Toothpick	No	Meckel's diverticulum	Chewing toothpicks	Recovery
1943 (1936)	Evans and Hanlon [13] (Hoff)	Acute appendicitis	?	?	Cecum	Toothpick	No	Cecum	Unknown	Recovery
1943 (1940)	Evans and Hanlon [13] (Shallow)	Not stated	?	?	Terminal part of ileum	Toothpick	No	Meckel's diverticulum	Hot dog	Recovery
1944	Hurwich [19]	Acute appendicitis	M	47	Right colic gutter	Toothpick	No	Cecum	Unknown	Recovery

Exploration revealed an abscess in the abdominal wall, with a toothpick 4 cm. long in the center of it. The patient could not recall swallowing the object.

The same year Vestal [8] reported the case of a white girl aged 9, who was admitted to the hospital with a diagnosis of acute appendicitis; onset was with mild pain three days before and severe abdominal pain and nausea two days before. Examination showed slight tenderness and muscular spasm in the right lower abdominal quadrant, and an indefinite mass was made out in the region of the appendix. The leukocyte count was 18,000, with 82 per cent polymorphonuclear leukocytes. A preoperative diagnosis of acute appendicitis with probable perforation and abscess formation was made. Operation revealed an abscess in the right lower quadrant of the abdomen, and resting on the floor of the cavity of the abscess was a slender, pale yellow piece of material, which on further examination proved to be an ordinary wooden toothpick. It had perforated the cecum on the anterior lateral aspect at a level with, and almost opposite, the ileocecal valve. It had penetrated through the intestinal wall only part of its length and was unbroken except for a slight "greenstick fracture" near its perforating end. The perforation was closed, the appendix removed and the abscess cavity drained, and the patient made a satisfactory recovery. After operation the child remembered having swallowed the toothpick while drinking water about nine days prior to her admission to the hospital. This case is one of the few in which the patient had any recollection of having swallowed the toothpick.

Wallis,[9] in 1930, reported the case of a man who was taken with a knifelike pain in the right side, the pain coming on in paroxysms, lasting a few minutes, then going away and recurring again. Two days after the first attack he was again seized with severe paroyxsms of pain accompanied with nausea. He was transported 4 miles (6.4 kilometers) to a physician, and a diagnosis of appendicitis was made. He was given ½ grain (0.032 Gm.) of morphine and then taken 78 miles (126.5 kilometers), by automobile, to a hospital. On arrival he was in great pain. The right rectus muscle was tense and rigid, and the point of maximum tenderness was halfway between the anterior superior spine and the umbilicus. The leukocyte count was 16,000, and a diagnosis of acute appendicitis with possible rupture was made. When the abdomen was opened, there was an escape of serosanguineous fluid with a fecal odor, and in the region of the ileocecal junction a small, hard object the size of a match was to be felt in the abdomen. On removal from the cavity it was found to be a whole toothpick, round, pointed and stained with fecal material. At a point on the posterior surface of the cecum, about halfway between the ileocecal junction and the

appendix, was observed a perforation about the size of a toothpick, with an area of induration around it. The opening was closed, the appendix removed and the abdomen closed with drainage. Recovery was uneventful. The patient denied having swallowed a toothpick but stated that he frequently used toothpicks after a meal and sometimes dropped asleep with one in his mouth. If his wife did not remove it, he would find it in his mouth on awakening. He also occasionally ate sandwiches which were held together with toothpicks. Evidently, he either ate the sandwich, including the toothpick, or fell asleep with the toothpick in his mouth and swallowed it while sleeping. Wallis [9] pointed out three points of interest: (*a*) the danger of using toothpicks in making sandwiches, the danger of sleeping with them in the mouth and the possibility of unconsciously swallowing them; (*b*) the peculiar location of the perforation, which was so closely associated with the appendix that the condition was diagnosed as ruptured appendix, and (*c*) the finding of the toothpick, which the author, realizing the difficulty frequently encountered in removing small foreign bodies from other locations in the body, regarded as a matter of luck and not skill.

In the same year McLanahan [15] reported the case of a man aged 44 who entered the hospital stating that on the previous day he first noted a dull pain in the right side of the abdomen. At times it was increased in intensity, with extreme tenderness in the right lower quadrant and a moderate degree of muscle spasm. A tentative diagnosis of appendicitis was made. Operation revealed a foreign body within the lumen of the cecum. Evidence of a small abscess was seen along the lateral wall of the cecum, with a small perforation leading into the abscess, and projecting through the hole was a small foreign body which proved to be a toothpick. Drainage and recovery followed. The patient had no recollection of swallowing the foreign body.

In 1931 Rivers and Davison [6] reported the case of a young woman (case 8 in their series) who came to the clinic because of nausea, vomiting and pain, with exacerbations of severe pain in the right lower abdominal quadrant. Soreness and pain occasionally radiated through to the back. Two years later the patient returned to the clinic complaining of spells of vomiting, regurgitation of greenish yellow, bitter fluid, and sometimes particles of undigested food, before and after meals. Dizziness always preceded vomiting. Menstruation made the vomiting worse. The function of the bowel was normal and the appetite good. Before vomiting the patient would have a sharp, knifelike pain in the left side. She thought she noticed some jaundice after vomiting. The

15. McLanahan, S.: Perforation of the Cecum by a Toothpick, Simulating Acute Appendicitis, J. A. M. A. **95**:1424 (Nov. 8) 1930.

pain was indefinitely situated. Exploration revealed a perforated duodenal ulcer about 4 cm. in diameter. It was buried in adhesions and was situated about 6 cm. below the pylorus; one point of a wooden toothpick was in the ulcer, and the other projected into the stomach. The upper part of the abdomen was filled with adhesions. Chronic appendicitis was present.

In 1934, McClintic [10] reviewed the literature and reported an additional case, that of a soldier aged 34 who was admitted to a station hospital complaining of abdominal pain. He had been in good health up to noon of the preceding day, at which time he was seized with severe pain across the lower part of the abdomen. Two hours later he took an effervescent saline cathartic. His bowels moved, and after this the abdominal pain became severer and was localized in the right lower quadrant. There was no nausea or vomiting at any time. The diagnosis was acute appendicitis, and the patient was sent to the hospital by ambulance. The abdomen showed mild localized tenderness under deep pressure over McBurney's point. There was no rigidity or rebound tenderness. The leukocyte count was 12,400. Because of the mild symptoms and the relief afforded by an enema, the operation was postponed for further observation. The next day the tenderness increased, was constant and was definitely localized. The preoperative diagnosis of acute appendicitis was made. Operation showed that the appendix was lateral to the cecum and attached throughout its full length by adhesions. Plastic lymph covered both the appendix and the lateral wall of the cecum. In this plastic lymph and in the cecum and the appendix opposite the ileocecal valve was observed a common wooden toothpick. The appendix was removed, with the stump inverted. Perforation was not observed in the appendix or in the cecum. The lateral wall of the cecum was raw and inflamed. The patient made a satisfactory recovery, and during convalescence was questioned about the toothpick. He had no recollection of ever having swallowed one but stated that when he was off duty he helped in a relative's restaurant and that frequently during the past year he had eaten three decker sandwiches held together with large toothpicks. Because of the location of the foreign body and the absence of a hole in the appendix, the author believes that in this case the cecum was the part that was perforated; however, the site of perforation was not discovered. The patient made an uneventful recovery.

In the discussion on Eitel's paper,[7] Dr. S. R. Maxeiner reported 7 cases, 1 of which (case 5) was referred for pelvic abscess. After an acute attack of abdominal pain which in every way resembled that of appendicitis, a tentative diagnosis of pelvic abscess due to ruptured appendix was made. However, on opening the abdomen the appendix

was observed to be normal, and when the abscess was opened a toothpick was observed to be penetrating a diverticulum of the sigmoid. The patient made an uneventful recovery.

In 1937 Donavan [16] reported the case of a boy aged 11, on whom operation was performed through McBurney's incision, with a diagnosis of acute appendicitis. A Meckel diverticulum, perforated by a wooden splinter (toothpick not specified) was removed.

In 1938 Henderson and Gaston [11] stated that between June 1, 1915 and Oct. 1, 1936, 800 cases of foreign bodies in the gastrointestinal tract had been observed at the Boston City Hospital; but, because the records were unsuitable for study, this series had to be narrowed down to 105 in which records could be carefully studied. Of this group, only 2 are of interest in this paper, and in these cases a splinter of wood appeared to be the offending object. A toothpick as a foreign body was not definitely identified. One case was that an 8 year old school boy, admitted to the hospital with abdominal pain of twenty-four hours' duration. A tender mass was felt just above Poupart's ligament. Exploration through a right rectus incision showed a normal appendix, but further exploration revealed a deeply injected piece of small bowel through which a wooden splinter had perforated. The surrounding intestine and mesentery were covered with fibrin, but there was no pus. The foreign body was removed through an opening in the bowel and was closed with a purse-string suture. The patient had an uneventful recovery.

Henderson and Gaston [11] also reported the case of a man aged 45 who entered the hospital complaining of abdominal pain of twenty-four hours' duration. He stated that a month previously he had had a period of four days in which he had suffered from abdominal cramps and diarrhea, which he attributed to food. Twenty-four hours before this he had felt well and had eaten a hearty meal of spaghetti; on the same day he was seized with sudden, severe epigastric pain, sharp and stabbing, and not radiating. Physical examination showed extreme tenderness in the epigastrium, with spasm of involuntary muscle throughout the upper portion of the abdomen. Tenderness was more pronounced just to the right of the midline. The leukocyte count was 20,000. Fluoroscopic examination showed no evidence of pneumoperitoneum. Operation through an upper right rectus incision revealed a moderate amount of clear serous fluid in the peritoneal cavity. A piece of wood 1½ inches (3.8 cm.) long was seen near the stomach. The omentum was adherent to the anterior wall of the pylorus, more particularly the first portion of the duodenum, and the point of perforation could not be found,

16. Donavan, E. J.: Meckel's Diverticulum Perforated by Foreign Body, Ann. Surg. **106**:953-954 (Nov.) 1937.

undoubtedly being under the adherent omentum. The wound was closed, with drainage. During convalescence the patient identified the small splinter of wood as being part of the seasoning used in cooking spaghetti, which he had eaten six hours before the onset of his acute symptoms.

In 1940 Melville [5] reported the case of a woman who one week before consultation had severe pain in the right lower abdominal quadrant. Castor oil aggravated the pain. She had signs of general peritonitis, with maximum tenderness in the right lower quadrant and a palpable mass in the right iliac fossa. Rectal examination revealed maximum tenderness in the right side. A right paramedial incision revealed a large inflammatory mass in the right iliac fossa. The omentum separated from this, and a wooden toothpick 2½ inches (6.3 cm.) in length was noted. It had perforated the ileum in two places. The perforation was closed and the pelvis drained; the patient had a stormy convalescence.

In 1941 McManus [4] reported the case of a man aged 65 who entered the hospital with generalized abdominal pain of forty-eight hours' duration. Abdominal tenderness was present; rebound tenderness was referred to the right lower quadrant, and exquisite tenderness was elicited just mesial to McBurney's point. A diagnosis of acute appendicitis was made. Operation revealed induration about the cecum. The appendix was less injected and was secondarily involved. Further exploration revealed a walled-off perforation of the lateral wall of the cecum from which a toothpick was protruding. The foreign body was removed, and the perforation was closed and drained; when the patient recovered, he could not recall swallowing the toothpick.

Barrett and Leader,[17] in 1942, reported the case of a white man who entered the hospital complaining of gradually increasing pain in the right lower quadrant and mild diarrhea for the past twenty-four hours. Physical examination revealed an elevation of temperature of 1 degree (F), tenderness and rigidity over the right lower quadrant and an area of spasticity over McBurney's point. The white cell count was 17,000. Operation revealed that the small intestine and cecum were inflamed, and on exposure of the cecum in the region of the terminal portion of the ileum there was observed a perforation from a toothpick, one half of which protruded into the peritoneal cavity and the other half remained in the cecum. The perforation was closed, the appendix removed and the wound closed with drainage. The patient made an uneventful recovery.

In 1943, Goehring [18] reported the case of a Negro aged 63 with cramplike pain around the umbilicus for a duration of ten days. He

17. Barrett, W. D., and Leader, L. R.: Perforation of Cecum by Toothpick: Case Report and Review of Literature, Harper Hosp. Bull. **1**:120-122 (May) 1942.

18. Goehring, W. O.: A Case of Toothpick Perforation of the Intestines, Am. J. M. Sc. **205**:807-808 (June) 1943.

was treated conservatively for four days. An abscess the size of a grapefruit formed in the lower part of the abdomen and was drained surgically. Twelve days after the patient entered the hospital there was still drainage, along with evidence of obstruction of the small bowel. Operation, performed thirty-six days after admission, revealed a foreign body granuloma containing a toothpick, which had first penetrated the transverse colon, and the ileum had later become impaled on the toothpick.

In 1943 Zieman [12] reported a case with a rather indefinite history, but the patient appeared decidedly ill. There was definite muscular rigidity over the entire lower part of the abdomen, with rebound tenderness referred to McBurney's area; fulminating appendicitis with probable rupture and peritonitis was suspected. When the peritoneal cavity was entered, serosanguineous fluid welled up into the field. The cecum was isolated and delivered, followed by an exceptionally long appendix. The appendix was only slightly injected, but the base of the cecum presented mottling of petechial spots, and a scarified, ulcerated lesion on the lateral aspect of the cecum was discovered. When the colon was rotated laterally, a black foreign body was seen perforating the center of a similar ulcerated area. The object appeared to be a fishbone and was firmly adherent to the bowel, necessitating removal with a hemostat. The appendix was removed, and examination of the foreign body later revealed it to be a toothpick encrusted with fecal deposit. The author stated:

> Conjecture as to the possibility of a person swallowing, unknowingly, a full length toothpick brought out certain interesting comments. First the patient had been accustomed to eating veal birds which were rolled and pinned together with toothpicks. The long baking of such morsels may have softened the wood sufficiently to cause it to lose its resistance. That one could swallow such an object betrays the careless mastication of the individual. However, considering the loss of touch sensation that can occur in a patient with upper and lower dentures, it is not only possible, but explanatory, as to the present instance.

In 1943 Evans and Hanlon [13] reported the case of a man aged 28 who entered the hospital three days after the onset of pain. Pain began in the right lower quadrant and increased in severity, and on the day of admission morphine gave only slight relief. He had nausea but no vomiting. He had two loose, watery bowel movements on the day of admission. A medical diagnosis of duodenal ulcer had been made two years before and treatment given. The temperature was 101 F. Examination revealed tenderness over the entire abdomen, but the greatest area of tenderness was over the right lower quadrant. Slight rigidity was present throughout the abdomen. Peristaltic sounds were diminished. Rectal examination revealed tenderness to the right. The leukocyte count

was 16,400, with 93 per cent polymorphonuclear leukocytes. The preoperative diagnosis was acute appendicitis. On opening the abdomen a small amount of cloudy fluid was observed; the appendix was retrocecal; the serosal surface was injected, but the gross appearance did not coincide with the clinical findings. Inspection of the terminal portion of the ileum revealed a Meckel diverticulum 1½ feet (45 cm.) from the ileocecal region. The diverticulum was ¾ inch (1.9 cm.) long and ⅝ inch (1.6 cm.) in diameter. The surface was covered with exudate, and a portion of a toothpick was seen to have perforated the diverticulum. Appendectomy and diverticulectomy were performed, and the patient made an uneventful recovery.

From the same article [12] is taken the report of a patient with a perforation of the cecum by a toothpick. The patient was operated on in the clinic in 1936 by Dr. G. W. Hoff, with recovery. The preoperative diagnosis also was acute appendicitis. Hanlon reported that he had attended the presentation of a case by T. A. Shallow in November 1940 in which a portion of a toothpick had perforated Meckel's diverticulum after the eating of a hot dog the night before. To date, that is 1943, this case had not been reported.

Hurwich,[19] in 1944, reported the case of a man aged 47 who was admitted to the Veterans Administration Facility at Los Angeles, with slight pain in the right lower quadrant. There was no nausea or vomiting or history of gastrointestinal distress. Examination showed extreme tenderness in the right lower quadrant, with rebound tenderness. The white cell count was 11,200. A diagnosis of acute appendicitis was made, and operation was performed soon after his admission. The peritoneal cavity contained a moderate amount of purulent fluid, which was removed by suction. The appendix appeared grossly normal. A long, sharp object was encountered in the right colic gutter, which on delivery proved to be an intact toothpick. A small perforation was observed about 1½ inches (3.8 cm.) from the ileocecal junction. Perforation was closed with drainage; the appendix was removed, and the patient made a good recovery. The patient was questioned but was unable to recall having swallowed a toothpick and stated that he seldom used one.

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DISCUSSION

DR. ERWIN R. SCHMIDT, Madison, Wis.: This paper illustrates well the situation that one encounters in the practice of medicine. One meets an unusual case and, after solving it, looks up the literature and finds that a fairly large number

19. Hurwich, J. J.: Perforation of Cecum by Toothpick, M. Bull. Vet. Admin. **21**:232-233 (Oct.) 1944.

of such cases have been reported over a period of years. They are lost in the literature and, unless one has an inquiring mind, will remain lost. Textbooks usually present reviews of the literature.

The author has emphasized some important points. I did not appreciate the association of dentures and the swallowing of foreign bodies, but I can readily see that the wearing of dentures is a definite factor.

Carp's work shows that the predilection for certain regions in the gastrointestinal tract is what one would suspect. The development of the lesion certainly must be accidental, for all physicians have seen foreign bodies pass through the tract with conservative management. The detection of arrest of the foreign body and the development of symptoms and early pathologic changes often defy the diagnostician. A scout film in obscure cases will often give the first evidence if the object is radiopaque. The history may or may not be helpful. If positive, it is helpful; if negative, it means nothing. Often the final diagnosis is made at operation or after examining the specimen.

The first case of a foreign body I have in mind was that of a student at Washington University, during the days of prohibition. The day was rather hot, and the best beer made in St. Louis was Busch's. This fellow had an enormous thirst, he had a way of drinking the beer out of the bottle, opening the bottle and tipping it up, and he could empty it into his stomach without stopping. He had pain after he had drunk his beer that day. He came to the outpatient department and was observed for some time, without a diagnosis being made. Eventually, someone took a roentgenogram and found that a sewing needle, the type of needle used to darn socks, had gone in through the esophagus, had penetrated the wall of the esophagus and was sticking into his heart.

I have a slide from a case reported by Dr. A. R. Curreri and Dr. D. W. Melick (*Wisconsin M. J.* **40**:192 [March] 1941), showing the foreign body. It was lodged in the appendix and was identified by the department of zoology as the vertebra of a rodent, either that of a squirrel or a rat. The patient had never eaten squirrel; he was not questioned about rat.

The patient gave a history of appendectomy for ruptured appendix three months before admission, followed by a persistent draining sinus. Excision of the fistulous tract was performed, and an abscess developed, which healed after incision and drainage. Two weeks later an intestinal obstruction developed and an abscess recurred in the right lower quadrant. The abscess was drained, and the obstruction improved with conservative management. Nine weeks later the patient was readmitted with a dull pain in the right lower quadrant. During the interval another abscess had formed and had been drained. An exploratory laparotomy showed dense adhesions around the terminal loops of the ileum and the proximal portion of the large bowel. Enmeshed in these adhesions was the appendix. This was removed, and on opening the appendix the vertebra was discovered. The patient made an uneventful recovery.

DR. FRANCIS E. CLOUGH, San Bernardino, Calif.: The wooden toothpick is the plebian thing one uses to pick the teeth with. The patrician type that we older fellows remember was a gold toothpick that slid back and forth in a case. Between the patrician and the plebian, all types of instruments have been used to pick the teeth.

A few years ago, a young woman with acute appendicitis was brought into my service. When I opened the abdomen, there was the appendix, acutely inflamed,

sticking up like a sore thumb. It felt very hard. I could not cut through it with the usual technic. There was something inside. Finally, I dissected through the wall with a sharp knife and pulled the appendix off from a pin.

The story was that the patient had been picking her teeth with a 3 inch (7.5 cm.) steel hatpin with a large black head. The pin had been swallowed. It had gone down into the intestinal tract and had entered the appendix, point first. The head was too large to get into the appendix and had stayed in the intestine. I had to open the cecum to withdraw the big head of the pin. The woman made an uneventful recovery.

DR. THOMAS J. SNODGRASS, Janesville, Wis.: I wish to thank Dr. Schmidt for his fine discussion and Dr. Clough for presenting this interesting and unusual case. Dr. Clough's case can be admitted to this group of cases because the foreign body, although it was metallic, was being used as a toothpick.

PRINCIPLES GOVERNING TOTAL GASTRECTOMY

A Report of Forty-One Cases

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IN THE progressive evolution of the scope of subtotal gastrectomy for cancer of the stomach, total gastrectomy has become a necessity in the armamentarium of the abdominal surgeon. From the operation of pylorectomy by Billroth in 1881 to total gastrectomy the entire history of modern surgical technic has developed, and yet the philosophy and approach to the more extensive procedures seem little changed in Lahey's [1] anaylsis of the problem in 1938: " . . . the operation is to be considered only in those cases in which a large part of the stomach is involved; extragastric metastases, even though they are not visible, and the operation is not justifiable if they are visible, are present in practically all of the cases. . . . In those cases in which the malignant lesion in the stomach is carcinoma, one cannot reasonably expect to be able to accomplish anything more than a prolongation of life but that with reasonable digestive comfort."

The operative technic has immeasurably improved in sixty-five years, but the pessimistic and futile point of view has remained unchanged. This does not imply that the operation is advocated solely for palliation, for the risks are too great, but in the face of definite indications, the handicaps and hazards must be accepted if progress is to be made in increasing the resectability of this most common and insidious cancer.

The key of the problem may be succinctly expressed by a paraphrase of Graham's [2] statement of attitude: The enthusiasm which the indi-

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From the Gastric Service of the Memorial Hospital for Cancer and Allied Diseases.

1. Lahey, F. H.: Complete Removal of the Stomach for Malignancy, with Report of Five Surgically Successful Cases, Surg., Gynec. & Obst. **67**:213-223, 1938.

2. Graham, R. R.: Total Gastrectomy for Carcinoma of the Stomach, Arch. Surg. **46**:907-917 (June) 1943.

vidual surgeon displays for this operative procedure will depend largely on his philosophy of life. If such philosophy demands that all efforts be used to prolong life, even though the effort be accomplished by grave immediate risk, and though the patient ultimately must die from carcinoma, providing he lives long enough, then such a surgeon must be an advocate of total gastrectomy.

We may say that though the purpose of the operation is curative, the result may be only palliative.

Krönlein [3] conceived the term of total gastrectomy as most definitive of the operation for gastric cancer, and stated that it included "only those in which both the pylorus and the cardia had been removed, and on which examination showed a portion of the esophagus at one end and the duodenum at the other end." He stated that the cardiac and pyloric sphincters should be removed. In 2 instances of subtotal gastrectomy in our series, the pathologist observed esophageal squamous epithelium and duodenal mucosa, but the operations have not been listed as total gastrectomies. The explanation of this paradox lies in the complete removal of the lesser gastric curvature and utilization of the fundus for the gastrojejunal anastomosis.

The historical development has been detailed in the collective review by one of us (G.T.P.)[4] of the literature up to July 1942, and report of the first 20 cases. Since the first known total gastrectomy in man, done by Conner,[5] of Cincinnati, in 1884, and the first successful one, by Schlatter,[6] of Switzerland, in 1897, the operation has been more enthusiastically extended, so that recent reports reveal gradually declining mortality rates and an increasing number of three and five year survivals.

PRINCIPLE OF TOTAL GASTRECTOMY

If an organ is unessential for life, the growing concept of cancer therapy more and more suggests the sacrifice of the entire organ, the regional lymph nodes which drain it and the intervening lymphatics. We do not advocate a discontinuance of subtotal gastrectomy as yet, because in our experience the deaths which have followed this more

3. Krönlein: Ueber die bisherigen Erfahrungen bei der radikalen Operation des Magencarcinoms (der Magenresektion und der Magenexstirpation) an der Züricher chirurgischen Klinik, Verhandl. d. deutsch. Gesellsch. f. Chir. (pt. 2) **27**:49-51 and 184-188, 1898.

4. Pack, G. T., and McNeer, G.: Total Gastrectomy for Cancer: A Collective Review of the Literature and an Original Report of Twenty Cases, Surg., Gynec & Obst. **77**:265-299, 1943.

5. Conner, P. S.: Report of a Case of Complete Resection of the Stomach, M. News **45**:578, 1884.

6. Schlatter, C.: Ueber Ernährung und Verdauung nach vollständiger Entfernung des Magens: Oesophagoenterostomie beim Menschen, Beitr. z. klin. Chir. **19**:757-776, 1897.

conservative operation have been due to metastases and not to local recurrence in the retained gastric segment.

The removal of the stomach and tributary lymph nodes en bloc is the ideal operation for gastric cancer and is the only technic which embodies the philosophy for excisions of mammary, colonic or rectal carcinoma, of epithelial carcinoma of the skin and appendages and of melanoma. The well planned total gastrectomy is both an excision of the entire stomach and dissection en masse of the related lymph nodes. The operation is designed to include the greater omentum, the lymphatics and nodes along the greater curvature, the nodes of the left gastropancreatic fold, the juxtacardiac nodes, the right gastroepiploic nodes, the infrapyloric and the retropyloric nodes, the lymph nodes of the lesser curvature, the gastrohepatic omentum, the nodes along the celiac axis and the nodes in the gastrosplenic ligament, and, if they cannot be separated from the spleen or if there is local extension into the spleen, the spleen itself is included in the en bloc dissection. It may even be feasible to include the peritoneum of the entire lesser sac in the dissection.

DISTRIBUTION OF CASES

Thirty-seven stomachs were resected for carcinoma, and 1 for an extensive reticulum cell sarcoma. Of the three lesions which proved to be benign, one was noncancerous linitis plastica, probably on a syphilitic basis, and two were large benign ulcers high on the lesser curvature.

In this group of patients undergoing total gastrectomy, 12 were women and 29 were men. The average age for the women was 53 years and 10 months, and for the men, 54 years and 7 months, with an over-all average for the 41 patients of 54 years and 5 months. In the 37 cases in which resection was done for gastric cancer, 26 patients were men, averaging 55 years and 9 months of age, and 11 of the patients were women, the average age being 55 years and 5 months, with an over-all average for the 37 patients of 55 years and 8 months. The youngest person in our series for whom total gastrectomy was done was a 30 year old Chinese man.[7] The oldest was a 79 year old white man.

SIGNS AND SYMPTOMS

Pain has been the initial complaint of 20 patients. There is nothing characteristic of this particular distress, because in some it was relieved by food, while in others it was constant and nothing afforded relief (table 1). A few complained only of vague discomfort. Anorexia was the presenting complaint of 5 and weakness of 4; indigestion was found

7. The patient of Lieut. Col. Willis M. Weeden, Medical Corps., 14th Evacuation Hospital, Army of the United States.

in 3, vomiting, belching and dysphagia in 2 each, and nausea, loss of weight and rapid satiation were the original complaints in 1 each. The history itself was never indicative of the type of procedure which would be necessary, and only roentgen and gastroscopic examination gave a clue as to the extensive operation demanded. As was found in the collective review of 162 patients for whom information was available, 75 per cent had symptoms of less than one year, and it was shown that the average duration of symptoms was eleven and seven-tenths months, as opposed to sixteen months in the series of patients for whom subtotal gastrectomy was indicated. In this group 29 of the 41 patients, or 75.6 per cent, presented symptoms of one year or less. The average duration of symptoms was eleven and seven-tenths months.

INDICATIONS FOR TOTAL GASTRECTOMY

1. *Location.*—The first and most important indication is the location and the extension of the disease found at laparotomy. If the tumor

TABLE 1.—*Initial Symptoms of Patients Operated On for Total Gastrectomy*

Total cases	41
Pain	20
Anorexia	5
Weakness	4
"Indigestion"	3
Vomiting	2
Belching	2
Dysphagia	2
Nausea	1
Loss of weight	1
Rapid satiation	1

Average duration of symptoms: 11.7 months.
Symptoms of one year or less: 29, or 75.6 per cent.

has extended to the cardiac lymph nodes from an original lesion in the pylorus, subtotal gastric resection is of no avail and total gastrectomy is the only feasible operation. This indication perhaps resolves itself to the fact that any tumor which cannot be completely removed by subtotal resection demands total gastrectomy (fig. 1). Postmortem examinations of subjects dying of untreated gastric cancer in reported series from the time of William Welch to the monographic report by Livingston and Pack [8] show a constant figure of 20 to 25 per cent of these patients with the cancer confined to the stomach without even demonstrable microscopic evidence of metastasis. Contraindication to operation in this group is perhaps the debility or poor physical condition of the patient, not age alone, as we have performed a total gastrectomy in a 79 year old subject.

8. Livingston, E. M., and Pack, G. T.: End-Results in the Treatment of Gastric Cancer, New York, Paul B. Hoeber, Inc., 1939.

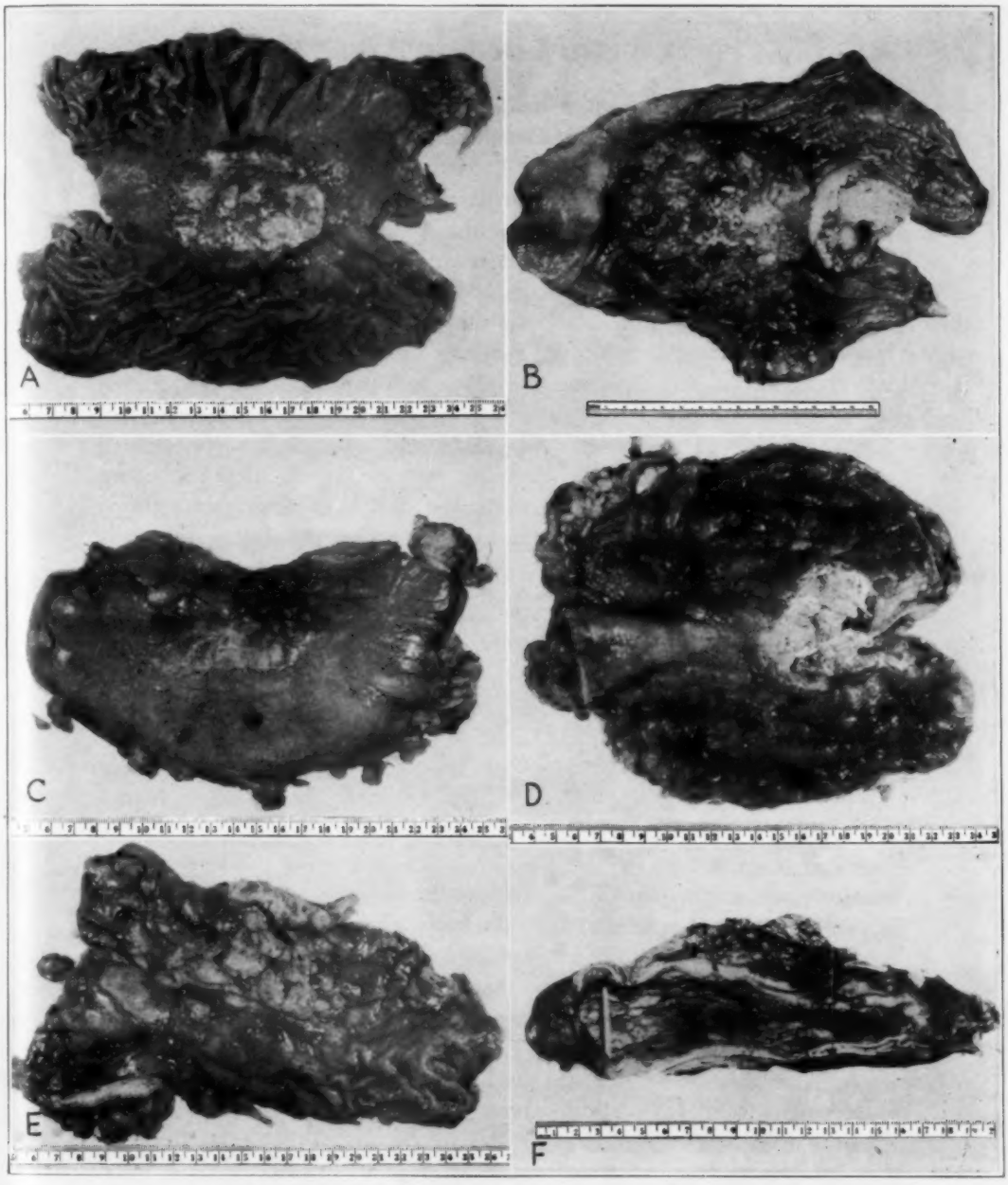

Fig. 1.—Specimens of total resection of the stomach. *A* (patient A. G.), photograph of gastric cancer arising along the lesser curvature showing an ulcerated tumor mass; the submucosal extension of the lesion is within 1 cm. of the margin of the cardia. *B* (patient I. G.), specimen is opened along greater curvature and shows a large polypoid mass occupying almost all of the lesser curvature. *C* (patient M. L.), specimen before opening, which shows infiltration of lesion into the lesser omentum. *D* (patient M. L.), specimen has been opened along the greater curvature and shows involvement of the greater portion of the stomach from cardia to within 3 cm. of the pylorus. The entire mucosa is hypertrophied and congested. *E* (patient H. M.), primary operable reticulum cell lymphosarcoma of the stomach. A large shallow ulcer occupies almost two thirds of the posterior wall along the greater curvature. *F* (patient D. S.), diffuse linitis plastica. Note the thickening of the submucosal layer and the intact mucosa.

In surgically resected total stomachs, the incidence of nodal metastases has varied in different clinics: Graham (Toronto General Hospital) reported 67 per cent; Lahey (Lahey Clinic) 87 per cent; Waugh and Fahlund (Mayo Clinic), 72 per cent; we (Memorial Hospital for Cancer and Allied Diseases) have encountered 62 per cent. Of course this cannot be construed to mean that local extension in itself is sufficient cause for assuming the added risk of the radical procedure. Finney and Rienhoff,[9] in analyzing the cases reported as total gastrectomies, showed that in removing the last 3 inches (7.6 cm.) of stomach left at the cardia the operative risk was much greater—53.8 per cent of 67 cases of authentic total resections—but in those in which less than 3 cm. was left at the cardiac or pyloric end, or both, 75 per cent of the 55 patients recovered, the mortality rate for the complete procedure being more than twice as great as for the radical subtotal gastrectomy. It therefore appears that when the local extent of the disease demands

TABLE 2.—*Total Gastrectomy—Location of the Lesion*

Location		Number	Percentage
Total		41	100.0
Proximal portion of the stomach—total		25	61.0
Cardia only	4		
Cardia with extension to the esophagus	1		
Lesser curvature and cardia	1		
Proximal one third	2		
Proximal one half	8		
Proximal two thirds	3		
Lesser curvature from pylorus to cardia	6		
Midportion of the stomach		7	17.1
Almost entire or entire stomach		9	21.9

greater effort on the part of the surgeon, the patient must also be capable of presenting greater resistance to the more formidable procedure if the operative mortality does not increase.

The accompanying table shows that in 61 per cent of our patients the cancers were situated in the proximal two thirds of the stomach and that in only 22 per cent was the entire stomach involved, indicative of the fact that these patients could not be afforded any hope by any operation short of total gastrectomy (table 2).

By encompassing lesions of greater extent and unfavorable locality, a greater resectability rate will result in greater numbers of three year survivals. In 1940 Abrahamson and Hinton,[10] in reviewing 444 cases of gastric carcinoma, found that 74, or 28 per cent, were located unfavorably for radical resection and that 135 cases showed roentgenologic evidence of carcinoma involving more than a single portion of the stomach,

9. Finney, J. M. T., and Rienhoff, W. F., Jr.: Gastrectomy, Arch. Surg. **18**: 140-162 (Jan., pt. 1) 1929.

10. Abrahamson, R. H., and Hinton, J. W.: Carcinoma of the Stomach, Surg., Gynec. & Obst. **71**:135-141, 1940.

and hence were unfavorable because of the extent of the lesion. While the 12 cases in their group 1, those showing involvement of the esophagus by extension, would necessitate transthoracic, transdiaphragmatic cardiectomy or total gastrectomy, the remainder might admit of salvage by complete gastrectomy despite the marked intragastric extension of the disease.

It has seemed to us that in extending the scope of the operation for gastric cancer, total gastrectomy offers the greatest opportunity to salvage more patients with this disease. From 1916 through 1945 there were 1,117 patients with carcinoma of the stomach cared for at the Memorial Hospital, of which number 759 underwent operation. A total of two hundred and twenty-seven resections have been performed, or in 20.3 per cent of those operated on, but if total gastrectomy had not been done, only 191 stomachs would have been resected, or 17.9 per cent, a difference of 2.4 per cent. The salvage rate would be 24 per thousand less the anticipated mortality of 31.7 per cent. This figure obtained by merely increasing the scope of the procedure seems far more gratifying than the salvage rate obtained even by mass surveys of asymptomatic patients of cancer age, as conducted by St. John, Swenson and Harvey.[11] They found a rate of 1.24 per thousand cases of patients over 50 years of age in the surgical outpatient clinic by conducting a routine gastrointestinal roentgenologic survey. By use of both transthoracic cardiectomy and total gastrectomy and abdominal total gastrectomy, a salvage rate of 60 patients per thousand cases has been effected in our series at the Memorial Hospital. This seems to indicate the most favorable and efficient means of improving the outlook for cancer of the stomach that is available today.

2. *Linitis plastica.*—Linitis plastica, because of its slow growth with complete involvement of the stomach and often without metastases, is always an indication for the radical procedure (fig. 2 *A*). This diagnosis was made four times in this present series; 1 instance was an inflammatory type of linitis, possibly of syphilitic origin.

3. *Lymphosarcoma.*—Lymphosarcoma, inasmuch as it sometimes is a diffuse infiltrating neoplasm which is often not distinguished preoperatively from carcinoma of the stomach, occasionally requires total resection. Of course with this diagnosis, postoperative roentgen therapy is definitely indicated as a prophylactic measure. Diffuse infiltrating sarcomas of the stomach are almost always lymphosarcoma and grow so rapidly that they sometimes do not seem amenable to surgical therapy. This type of lesion, however, when no extragastric

11. St. John, F. B.; Swenson, P. C., and Harvey, H. D.: An Experiment in the Early Diagnosis of Gastric Carcinoma, Ann. Surg. **119**:225-231, 1944.

extension can be demonstrated, demands exploration to determine the feasibility of total gastrectomy.

4. *Malignant Leiomyoma or Leiomyosarcoma.*—Malignant leiomyoma or leiomyosarcoma is another tumor which may require total gastrectomy because the lesion grows rapidly and attains large size, but this tumor is usually well circumscribed and easily extirpated.

5. *Multiple Polyposis, Diffuse Polyposis en Nappe or Polypous Gastritis.*—Multiple polyposis, diffuse polyposis *en nappe* or polypous gastritis may occasionally justify a radical resection, depending on the extent of the disease. If any involved part of the stomach is allowed to remain in these cases, the danger from hemorrhage or development of cancer may be as great as if a subtotal resection were not done.

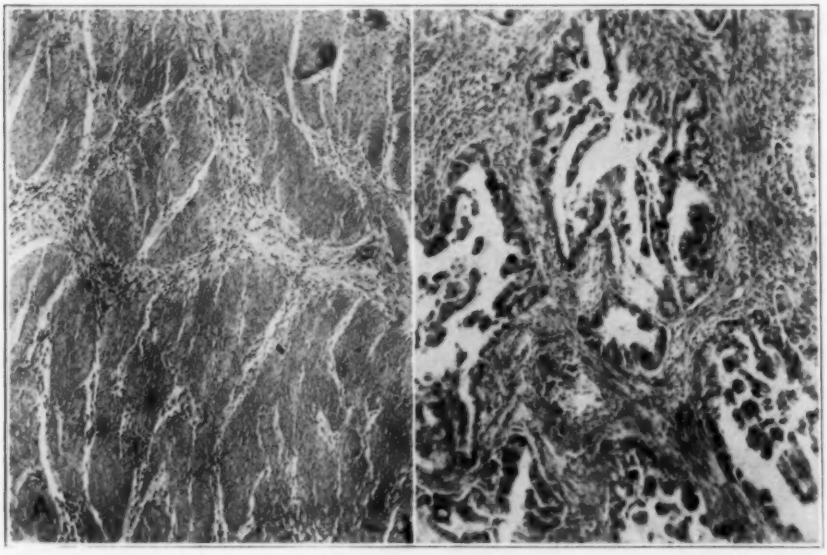

Fig. 2.—*A* (patient D. S.), photomicrograph through muscular wall of the stomach involved by linitis plastica, showing the diffuse extension of the tumor process between muscle bundles. × approximately 185. (The gross specimen is shown in fig. 1 *F*.) *B* (patient G. W.), photomicrograph of specimen of fungating tumor showing an adenoma malignum, grade II. This tumor extended to less than 1 cm. from the line of resection (a roentgenogram of the patient is shown in fig. 4 *A*). The patient was living without evidence of recurrence when last examined, forty-three months after operation. × approximately 185.

6. *Gastric Ulcer High on the Lesser Curvature.*—Gastric ulcer high on the lesser curvature, which even after exploration appears to be carcinomatous, may demand total gastrectomy on the clinical assumption of its malignancy. In a patient of our series, the ulcer was thought to be carcinomatous but proved to be a benign peptic ulcer high on the lesser curvature. Another gastric ulcer, properly diagnosed as benign

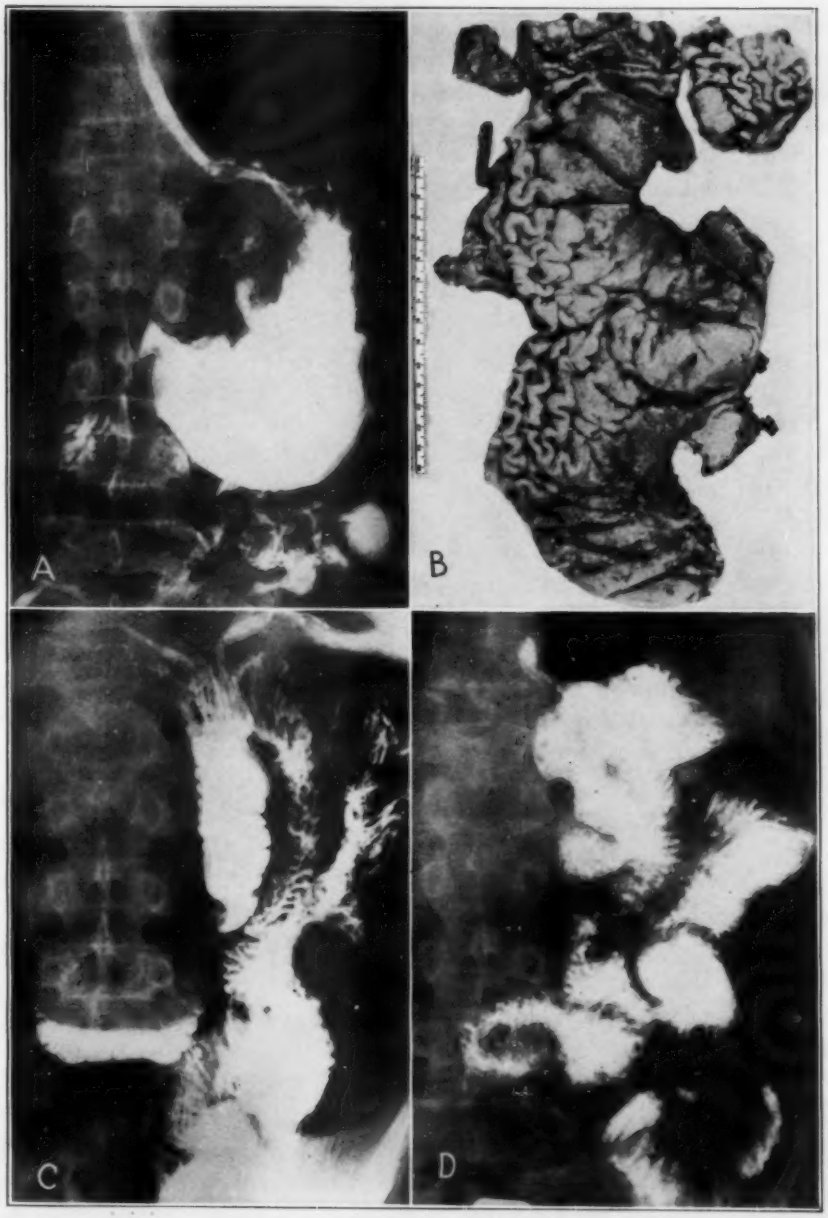

Fig. 3.—J. R., a 43 year old man, had symptoms of gastric obstruction for one month. Extensive ulceration demanded total gastrectomy. *A*, preoperative roentgenogram showing a small preantral crater and a definite narrowing of the antrum. A large outpocketing on the lesser curvature of the pars media was thought to be a diverticulum but in reality was a huge ulcer. *B*, photograph of the resected specimen. The stomach was extremely friable and in the process of mobilization, the posterior wall tore, leaving part of the specimen adherent to the pancreas. The ulcer on the posterior wall measured 10 by 5 cm. *C*, gastrointestinal series one month after operation showing esophagojejunostomy with a large fistula. There is mild dilatation of the duodenum. *D*, gastrointestinal roentgenograms forty months after operation, showing normally functioning esophagojejunostomy with barium descending through the jejunal loops.

before operation, required total gastrectomy to remove the adjacent inflamed stomach wall (fig. 3). Jones and Kehm [12] reported that in their 10 patients, 2 were subjected to this radical procedure because of penetrating ulcers high in the cardia which were intractable under medical management, while five of the seventy-seven total gastrectomies in the Mayo Clinic series were performed for benign ulcers, which were impossible to tell from malignant ulcers.[13] Abdominal cardiectomy or resection of the proximal half or more of the stomach with a subdiaphragmatic esophagogastrostomy is sometimes feasible. We have done this on a few occasions; the variety of subtotal gastrectomy would seem preferable to total gastrectomy, especially in the case of benign lesions.

Certain technical indications must obtain: 1. The lesion must be confined to the stomach, tributary nodes and immediate perigastric tissues, and no distant metastases should be present. 2. There must be sufficient mobile esophagus above the lesion to allow at least 3 cm. of clear margin beyond the apparent limit of involvement and enough added esophagus for the anastomosis after this resection. We concur with de Amesti [14] who quotes Verbruggen's work which shows intramural extension 3 to 4 cm. beyond the gross limits of the tumor in 40 operative specimens. Accordingly, he believes that there should be at least 3 cm. of free margin above the resection. One of our patients, in whom the pathologist reported submucosal extension of a grade III gelatinous cancer at the line of esophageal section, lived two years following transthoracic total gastrectomy. Another patient with an adenoma malignum, grade II, which extended to less than 1 cm. from the line of resection, was alive without evidence of recurrence when last examined, forty-three months after operation (fig. 2 *B*). 3. Although the incidence in which involvement does not extend beyond the stomach into the perigastric lymph nodes varies from 13 to 38 per cent in different groups, it does not follow that this alone determines resectability, because the patient must be at least a fair operative risk to withstand the procedure.

ROENTGENOGRAPHY AND GASTROSCOPY

Fluoroscopic examination of the stomach is perhaps the most important and easiest means of determining the extent of invasion of the tumor, because submucosal involvement of the cardia or pylorus may be revealed by alteration of motility and rugal pattern that is not apparent

12. Jones, T. E., and Kehm, R. W.: Total Gastrectomy, Surg., Gynec. & Obst. **80**:534-538, 1945.

13. Waugh, J. M., and Fahlund, G. T. R.: Total Gastrectomy, S. Clin. North America **25**:903-917, 1945.

14. de Amesti, F.: Total Gastrectomy for Cancer, Ann. Surg. **117**:183-190, 1943.

on roentgenograms. Roentgenologic examination usually reveals the extent and type of the lesion (fig. 4), but esophagoscopy may be necessary to determine the upward involvement of the cardia and esophagus. If esophagoscopy shows extension beyond the stomach, then transthoracic,

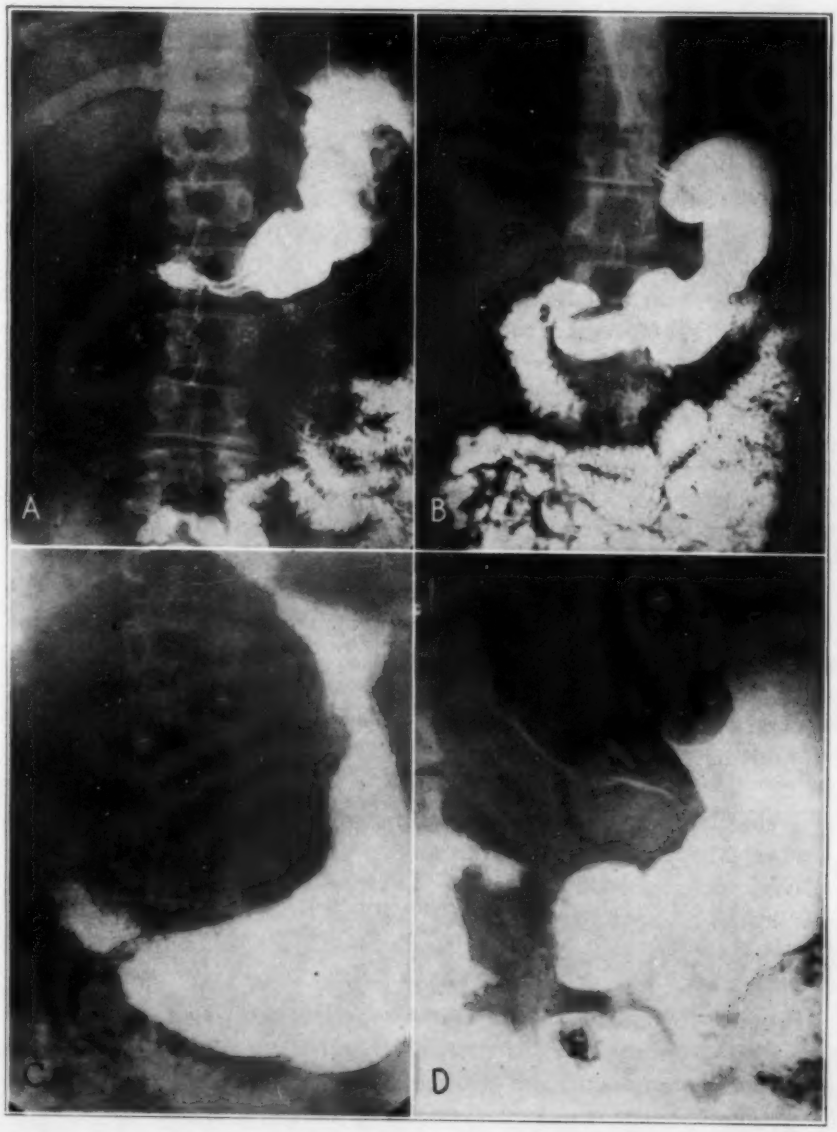

Fig. 4.—Roentgenograms of bulky carcinomas involving the proximal half of the stomach, all successfully removed by total gastrectomy. *A* (patient G. W.), large polypoid tumor involving the pars media, corpus and fundus of the stomach. *B* (patient J. C.), large tumor occupying the proximal half of the stomach. *C* (patient D. G.), a bulky carcinoma involving the lesser curvature of the stomach near the cardia. *D* (patient A. Z.), a polypoid lesion of the proximal half of the stomach.

and not abdominal, exploration is in order. If roentgenologic studies show freedom of the cardia, the type of lesion can be determined with the flexible gastroscope.

PREOPERATIVE CARE

These patients are hospitalized at least five days before operation for complete evaluation of their physical status. Medical consultation determines whether the patient's cardiovascular system will tolerate the risk. A low residue, high protein diet is forced, if possible, and if it is not tolerated, the same nutrition is incorporated in a liquid diet. The red cell count and hemoglobin level are restored with transfusions, as well as depleted serum protein. Hard candies and fortified fruit juices are forced to replenish depleted hepatic glycogen stores and to mobilize hepatic lipids. Daily—and, if there is any obstruction, twice daily—gastric aspiration and lavage with tenth normal hydrochloric acid are performed to reduce the bacterial count of the pathogenic organisms uniformly present in this type of case. The patients are sent to the operating room with an indwelling nasal Levine tube.

ANESTHESIA

The anesthesia of choice in this entire series, except for transthoracic, transdiaphragmatic total gastric resection, has been continuous spinal anesthesia. It has been attended by uniformly good relaxation in a difficult approach. A 2.5 per cent solution of pentothal sodium has been given intravenously for restlessness and apprehension. One operation of transthoracic total gastrectomy was done with the patient under ether and nitrous oxide-oxygen anesthesia with controlled breathing. We have not used local and splanchnic block as de Amesti [14] and McCorkle and Silvani [15] advocated. Our series contrasts with Waugh and Fahlund's [13] series, in which intratracheally administered ether was the agent of preference and in which group spinal anesthesia was not used. Spinal anesthesia has not increased the tendency to shock, as some authors believe it does, nor has it been too effective in warding off pulmonary complications, as we had previously believed.

OPERATIVE TECHNIC

In only 1 patient has a transthoracic, transdiaphragmatic total gastrectomy been done. If the preoperative roentgenographic and gastroscopic studies indicate the necessity for total gastrectomy and if the distal esophagus is not involved the transabdominal approach is preferred. The transthoracic approach is considered the one of choice if

15. McCorkle, H. J., and Silvani, H. L.: The Technique of Total Gastrectomy with Particular Reference to the Use of Local Anesthesia, S. Clin. North America **23**:1465-1475, 1943.

there is esophageal obstruction, whether the tumor is primary in the stomach or the esophagus.

In these forty-one total gastric resections, gastrointestinal continuity was established by esophagojejunostomy in all except 1 case, in which esophagoduodenostomy was done. The greater ease with which the esophagus is anastomosed to the jejunum, as opposed to the tension under which esophagoduodenostomy is effected, has caused us to abandon the latter procedure entirely. A mortality rate of 40.7 per cent in the collected reports in which esophagoduodenostomy was performed, as opposed to 33.9 per cent of the collected cases of esophagojejunostomy, indicates a definite superiority of the latter technic.

A midline incision in the upper part of the abdomen has been the approach of choice, with the lower pole of the incision veering just to the left of the umbilicus if any more exposure is necessary, though a left paramedian incision has been used in about an equal number of cases. A routine abdominal exploration precedes the decision of resectability. A definite routine of exploration must show freedom of extension in seven regions: 1. By palpating through the foramen of Winslow the hepatoduodenal ligament is palpated for evidence of extension or infiltration of the cancer toward the portal fissure. 2. The gastrohepatic ligament is broken through to ascertain whether lymphatic extension around the celiac axis precludes resection. If there is sufficient margin to allow even a close division of the origin from the celiac axis, the celiac lymph nodes and the origin of the left gastric artery can be readily stripped off together. 3. The spleen is visualized to determine the extension of the cancer into the gastrosplenic ligament and to determine whether splenectomy will be necessary in order to excise the lesion en bloc. 4. The abdominal part of esophagus is palpated to determine its mobility and the extension of the cancer past the cardia and to estimate whether there will be sufficient length of esophagus after mobilization to effect an anastomosis. 5. Then the posterior wall of the stomach is inspected to detect any possible extension into the peripancreatic capsule. 6. The superior surface of the transverse mesocolon is examined to ascertain freedom from invasion of the middle colic vessels. 7. Finally, the cul-de-sac is palpated to determine the presence of cancer deposits.

After these maneuvers it still may be impossible to determine the resectability of the stomach, and the operator may have to proceed in mobilizing the stomach to determine this fact. Until the duodenum is transected, an irreversible decision for proceeding with the operation does not have to be made because of the extreme vascularity of the stomach and its remarkable viability, even after three of its four major vessels have been severed.

In the process of mobilization an en bloc dissection of the stomach, perigastric nodes and omentum must be planned to effect "an excision and dissection in continuity." The greater omentum is freed along the avascular reflection on the transverse colon from the gastroduodenal angle to the splenic flexure, including the juxtacardiac nodes, the nodes of the left gastropancreatic fold and the lesser curvature, the right gastroepiploic, the infrapyloric and the retropyloric nodes,

the retropancreaticoduodenal node, the left gastroepiploic nodes and any nodes along the gastrosplenic ligament. If there is extensive invasion of the ligament it may be necessary to include the spleen in the dissection, though we do not employ this as a routine procedure.

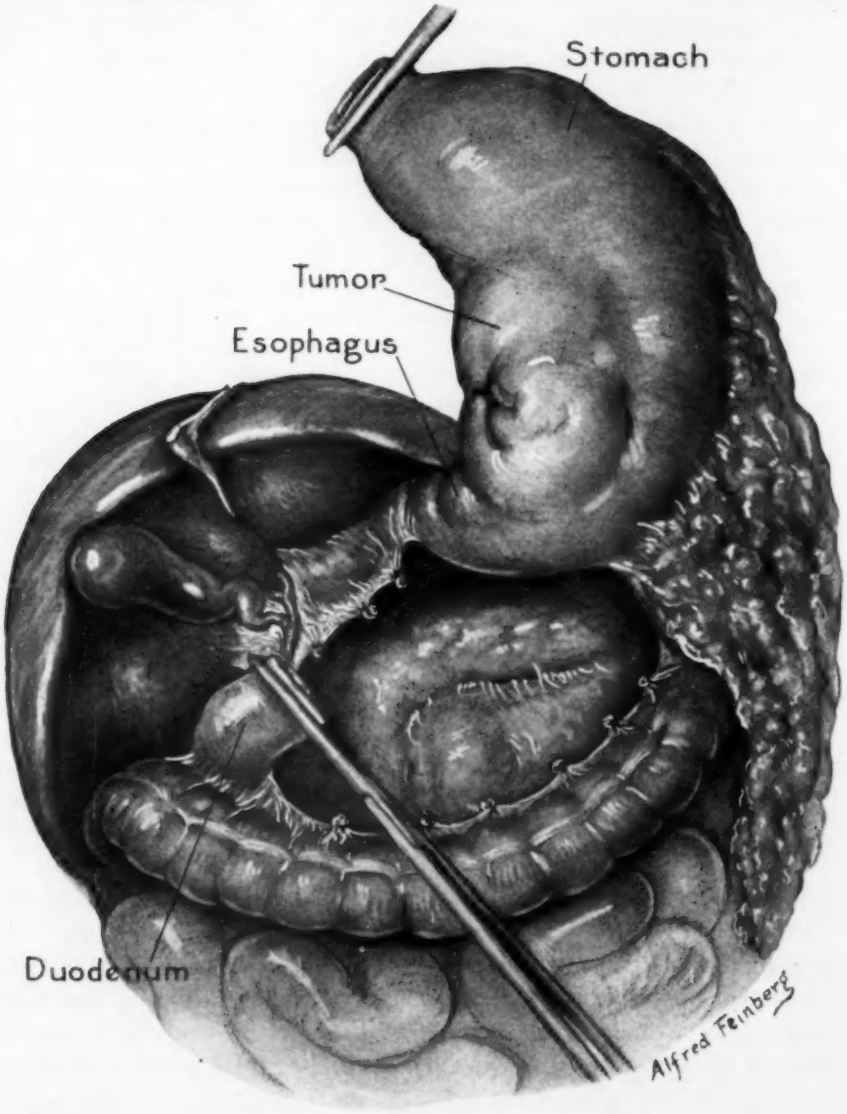

Fig. 5.—Technic of total gastrectomy. The duodenum has been transected after ligating the right gastric, the gastroduodenal and the right gastroepiploic vessels and after resecting the omentum along the reflection over the transverse colon.

When resectability has been established, the duodenum is mobilized and transected after ligation of the right gastric, the gastroduodenal and right gastro-

epiploic arteries and veins (fig. 5). Our choice of closure of the duodenal stump has been the Parker-Kerr basting stitch technic, reenforced with silk Lembert sutures, although the DePetz mechanism has been used in place of the basting stitch closure in a few instances. The peripancreatic capsule is sutured over the

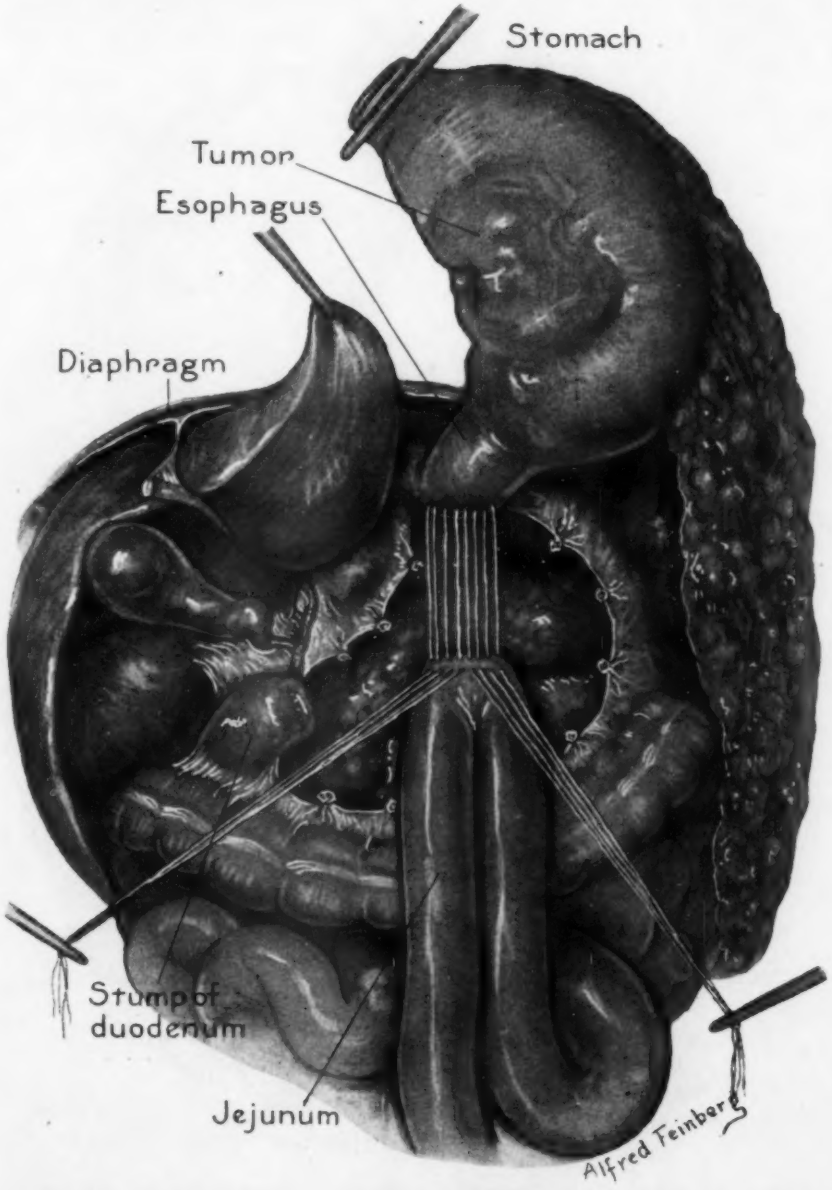

Fig. 6.—The technic of total gastrectomy. Exposure after cutting the left leaf of the triangular ligament of the liver and reflecting the left lobe of the liver forward. Interrupted mattress sutures between esophagus and jejunum have been placed with the viscera widely separated. The jejunum is being slid into position.

stump. The open pyloric segment is carefully wrapped with a dry laparotomy pad to avoid contamination and the cardia is then mobilized. The short gastric arteries are ligated, after freeing of the gastrolienal ligament, and, with the mobility thus afforded, the left gastric vessels can be easily approached, clamped, cut and

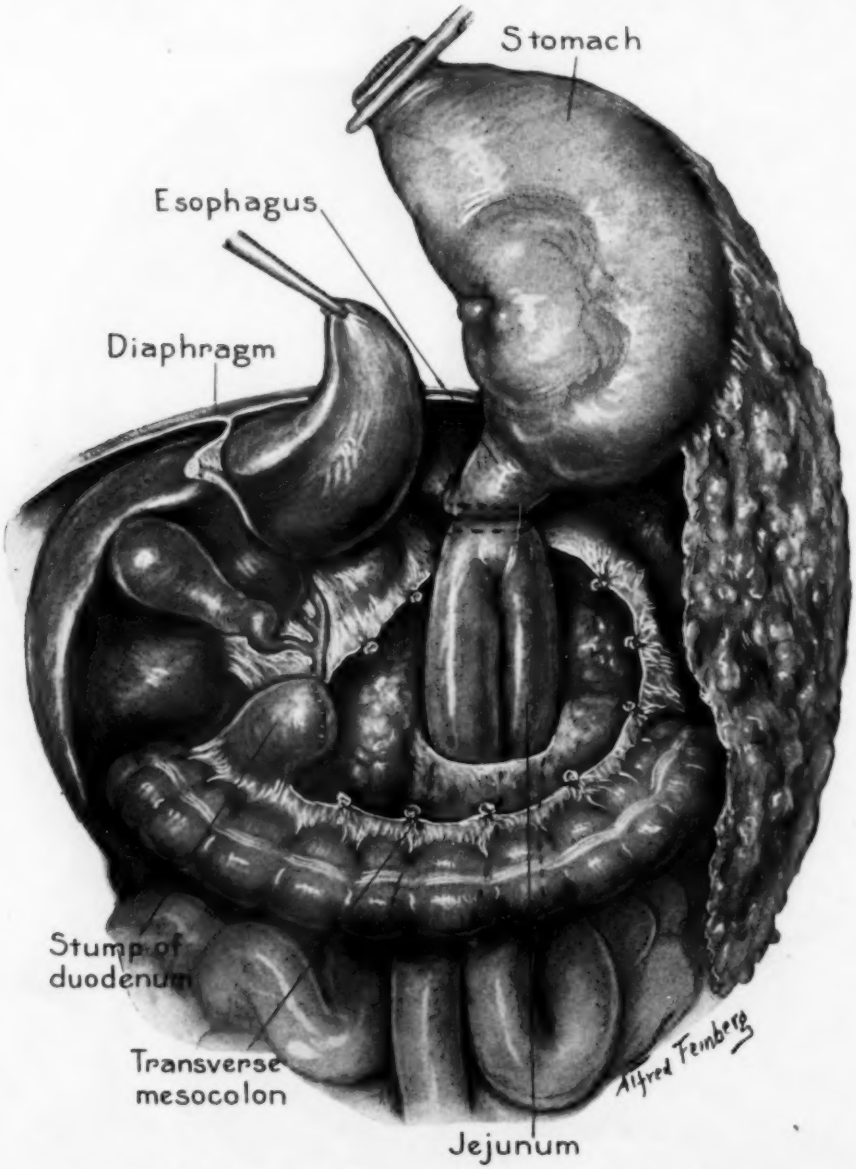

Fig. 7.—Technic of total gastrectomy, showing retrocolic type of anastomosis. The lines of incision into the esophagus and jejunum are shown.

ligated with a suture ligature. The left triangular ligament of the liver is severed so that the left lobe of the liver can be retracted medially to afford a better

exposure of the esophagus. At this time peritoneal flaps are prepared from the diaphragm, both anteriorly and posteriorly to the esophagus; then by blunt digital dissection the esophagus is mobilized through the hiatus of the diaphragm so that up to 5 cm. more esophagus can be brought through the diaphragm to aid in making the anastomosis and relaxing the tension on it.

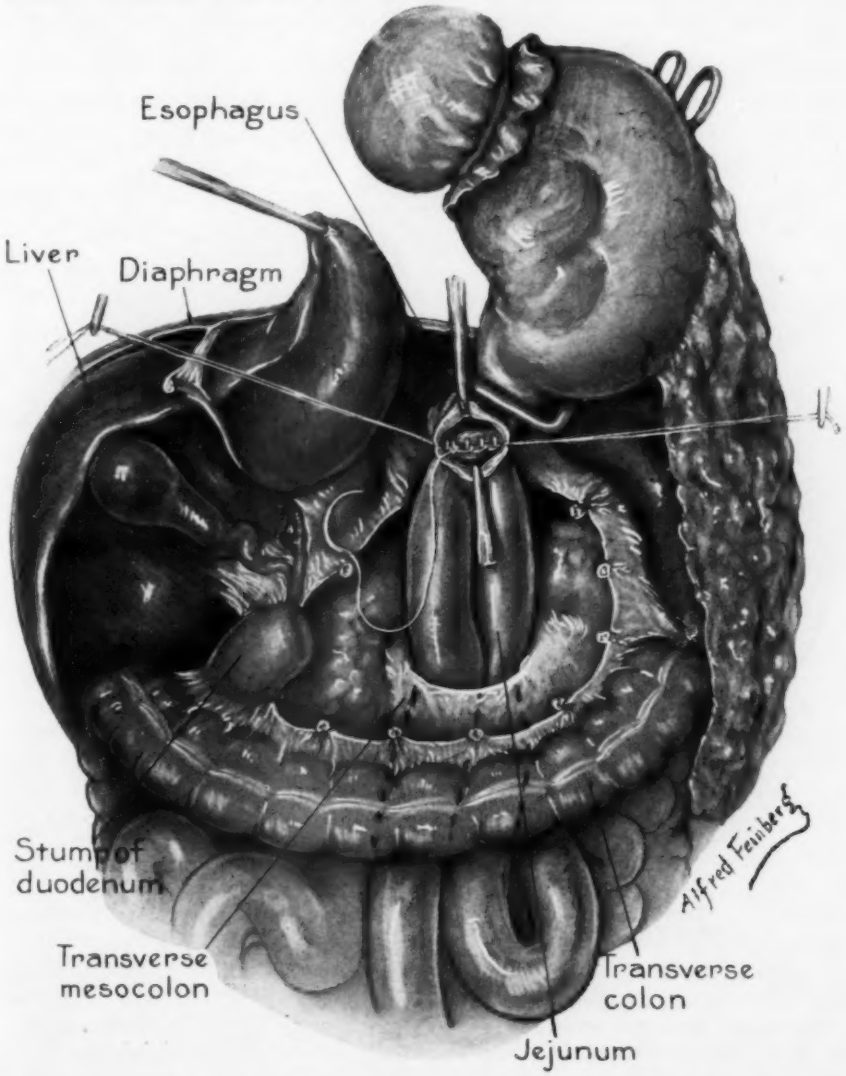

Fig. 8.—Technic of total gastrectomy. A right angle kidney clamp prevents reflux of gastric contents into esophagus. The third layer of posterior sutures is in place.

The decision as to whether to form a retrocolic or an antecolic anastomosis depends in great part on the length of the jejunal mesentery, but in most cases an antecolic anastomosis is to be preferred. In the latter case a long afferent

jejunal loop is created of at least 10 to 15 inches (25.4 to 38.1 cm.) in length. We do not believe in first affixing the jejunum to the diaphragm before creating the anastomosis because we have found it much easier to place the posterior seromuscular-muscular layer of interrupted silk mattress sutures with the jejunum at some distance from the esophagus (fig. 6). After the sutures have been placed, with the attendant good visibility, the jejunum can be slid up to its proper position

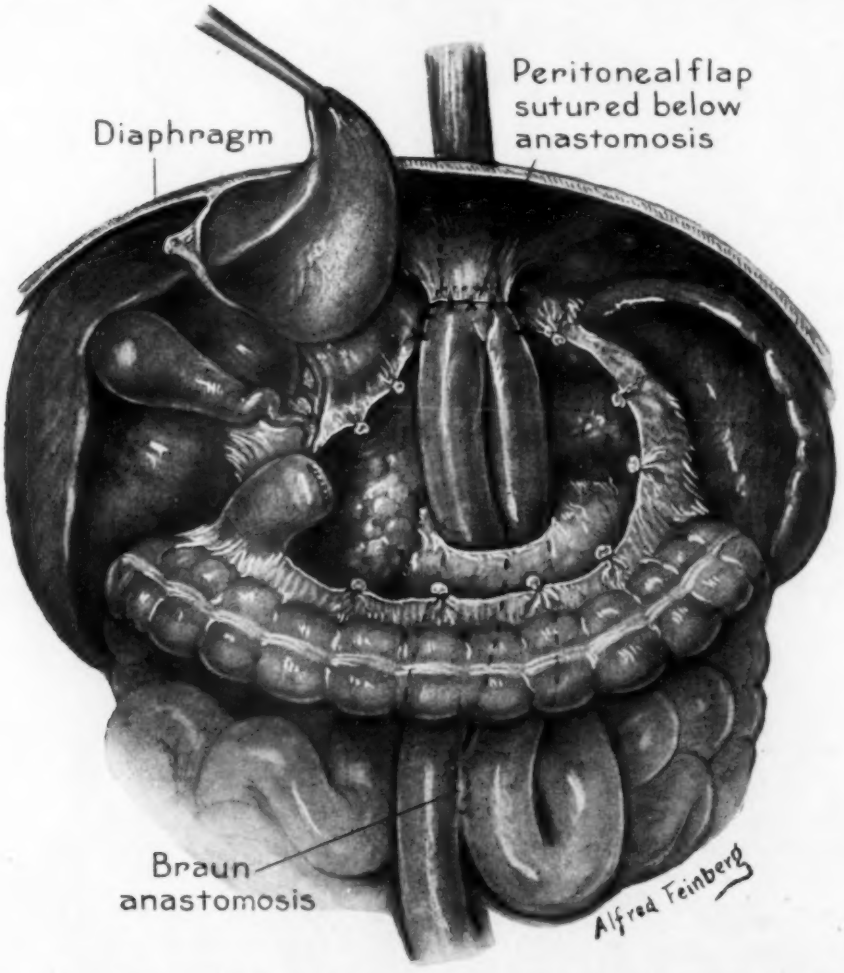

Fig. 9.—Technic of total gastrectomy. The peritoneal flap is sutured below the line of the anastomosis and the lateral jejunojejunostomy has been completed.

and the sutures tied. Incisions in both esophagus and jejunum are then made (fig. 7) down to the mucosa and a posterior layer of fine chromicized surgical gut is placed and tied. A continuous mucosal suture of surgical gut is inserted before the specimen is resected (fig. 8); the suture is locked, to avoid purse-string constriction of the stoma, before the anterior layer is introduced as a Connell running suture. The remaining anterior layer of silk sutures is placed and the

diaphragmatic flaps then sutured onto a lower level of the jejunum (fig. 9). Tension on the suture line is relieved by suturing the afferent and efferent loops to the diaphragm lateral to the anastomosis.

We now routinely use an indwelling Levine tube to place the anastomosis at complete rest, and at this stage of the operation the anesthetist advances the tube so that the operator can guide it into the distal lumen of the jejunum for a distance of 12 to 16 inches (30.5 to 40.6 cm.) for orojejunal feeding purposes.

In all except 5 of our 41 cases we have performed a jejunojejunostomy, an incidence of 87.8 per cent. While Lahey has abandoned this procedure entirely, it was used in 46 of the 77 cases of Waugh and Fahlund.[13] With the Roscoe Graham technic, the supplementary enteroenterostomy or Braun anastomosis is a necessity. It is of great advantage to have the bile and pancreatic juices in the proximal limb pass through the anastomosis into the distal loop. It also would appear that this relieves pressure on the duodenal stump in the immediate postoperative period.

Two Penrose drains are placed, the ends of each on either side of the anastomosis and brought out through the superior pole of the incision; 5 to 10 Gm. of powdered sulfanilamide is sprinkled along the line of anastomosis and over the duodenal stump. The peritoneum is closed with a continuous suture of chromicized surgical gut and the fascia is repaired with interrupted sutures of fine black silk and vertical mattress sutures of black silk to the skin. Because patients with gastric cancer have been more prone to wound disruption and in collected series of wound disruptions [16] head all other groups in incidence of wound dehiscence, figure of eight braided silk retention sutures are routinely used and are not removed until the fourteenth postoperative day. No case of evisceration has occurred in this series.

At the end of the operation, if the patient's condition permits, eucupine (isoamylhydrocupreine) in oil is injected into the sixth to the eleventh intercostal nerves along the posterior axillary line, 3 cc. for each nerve, the procedure being done on both sides if the midline incision is used. If this procedure is done, the vital capacity is not impaired and pulmonary complications are less apt to occur.

POSTOPERATIVE CARE

If the patient is in shock at the conclusion of his operation, he is transferred directly to his bed in the operating room so that unnecessary handling will not aggravate the condition. Blood transfusions have been used liberally with at least one to two 500 cc. transfusions, even up to four being given during the operation in order to forestall shock. Blood or plasma and the Trendelenburg position are continued until the blood pressure and pulse are stabilized. Subsequent blood replacement is given with due respect to blood cell count and total protein levels determined at two day intervals.

All patients are routinely placed in an oxygen tent on their return from the operating room, and oxygen is administered at least twenty-four hours. As soon as there is no respiratory distress, this treatment is discontinued. Blow bottles,

16. Jenkins, H. P.: A Clinical Study of Cat Gut in Relation to Abdominal Wound Disruption, with a Test of Its Tensile Strength on Patients, Surg., Gynec. & Obst. **64**:648-662, 1937.

forced respiration, change of position at least every two hours and sitting-up posture in bed are routine to encourage adequate respiratory excursion. Tracheal suction with catheter or bronchoscopic aspiration is used as soon as the patient fails to raise the bronchial secretion himself. Formerly sulfonamide drugs were routinely used without appreciable prophylactic benefit. Now penicillin, both intramuscularly and, more recently, as aerosol inhalations, has been used prophylactically, but there have not been enough patients in this time to evaluate its efficacy in preventing pulmonary complications.

The patient is forced to dorsiflex his feet and to move his legs to encourage the femoral circulation and to prevent postoperative thrombophlebitis. Pulmonary embolic accidents have not occurred in this series. Unless some unusual contraindication exists, the patient is out of bed and ambulatory within forty-eight hours.

Three ounce (89 cc.) feedings of albumin water are given through the indwelling Levine tube three hours after the patient returns from the operating room and, thereafter, at three hour intervals for the day of the operation. Feedings are gradually increased from 1,280 calories on the first postoperative day, by giving alternate 4 ounce (118 cc.) feedings of albumin water and peptonized milk, up to 3,000 calories on the ninth day, by a special formula. This contains 118 Gm. of protein on the last day of feeding, so that this most essential element of postoperative alimentation is not slighted. Fluids given parenterally are also necessary the first three or four days. Supplemental polyvitamin therapy is given in the tube, with especial attention to vitamin B complex, to ward off gastrointestinal hypomotility.

Jejunostomy has been used in 16 cases, but more recently we have not used it. Jejunostomy is done in the efferent limb, distal to the Braun anastomosis. Several of our patients in whom the Levine tube was not sutured in the nose have pulled the indwelling tube out so that it was necessary to start them on oral feedings, which we have never hesitated to do so far as we lack no confidence in the security of the anastomosis. Yet it has never been possible to give the adequate alimentation which these patients demand, for despite intensive preparation to restore protein balance, adequate protein reserves for the early restricted postoperative course of at least ten days cannot be established in the preoperative management. Maintaining high protein, as well as caloric, intake has been the prime consideration in favoring an indwelling Levine tube for ten days postoperatively, though we also feel that enforcing physiologic rest at the site of the anastomosis is almost equally important.

In Waugh and Fahlund's series of 77 cases, postoperative nutrition was maintained by a jejunostomy tube in 54.5 per cent and by a nasal tube passing to the distal lumen of the jejunum in 27.3 per cent of the cases, while in 18.2 per cent no method of tube feeding was used. As they compared these three groups they felt that the hospital survival rate was roughly the same except that the slightly lower survival rate in the patients having jejunostomies could be attributed to the fact that this procedure was used in patients who were poorer risks.

Analysis of our series has revealed a significant factor which may overshadow the advantage of maintaining protein balance with an orojejunal Levine tube. In the 16 cases in which a jejunostomy has been done, there were four operative deaths, only one of which was due directly to a pulmonary complication, while among the 25 patients who had Levine tube feedings there were five deaths. It is apparent that the irritation from a foreign body in the nose and throat may cause considerable nasopharyngeal secretion, and with the voluntary protective splinting of the pharynx possibly depressing the cough reflex pulmonary complications may be invited. There may be reason to withdraw the tube much earlier than ten days and rely on a less nourishing routine.

TABLE 3.—*Operative Deaths Following Total Gastrectomy*

	Patient	Age	Sex	Jejunostomy (J) or Levine Tube (LT)	Direct Cause of Death	Postoperative Day of Death
3.	L. W.	42	M	J	Bronchopneumonia *	8th
4.	O. B.	50	M	J	Peritonitis	7th
9.	G. M.	62	M	J	Anuria	3rd
13.	L. S.	65	M	J	Subdiaphragmatic abscess	12th
18.	H. M.	57	M	LT	Atelectasis and pneumonia *	4th
19.	J. G.	58	M	LT	Bilateral bronchopneumonia *	19th
26.	A. G.	70	M	LT	Cardiac insufficiency and renal failure	30th
27.	A. W.	68	M	LT	Bronchopneumonia and cardiac failure *	6th
29.	L. S.	68	M	LT	Bilateral bronchopneumonia	3rd
33.	L. L.	70	M	LT	Cardiac failure	6th
38.	H. M.	52	M	LT	Peritonitis (postmortem diagnosis)	9th
34.	J. B.	44	M	LT	Pneumonia	3rd
39.	L. S.	65	F	LT	Cardiac failure	9th

	Number	Percentage
Pulmonary complications	6	46.1
Cardiac failure	3	23.1
Peritonitis	3	23.1
Anuria	1	7.7

* Patient also had hypoproteinemia.

POSTOPERATIVE DEATHS

In the series of 41 total gastrectomies there have been 13 operative deaths, an over-all mortality rate of 31.7 per cent. In the original series of 20 cases there were six deaths, representing an operative mortality rate of 30 per cent.

There were three principal immediate complications (table 3). Those of pulmonary origin head the list, 6 of which led to death; all were due to pneumonia and one was preceded by massive atelectasis. Pneumonia thus accounted for 46.1 per cent of the operative fatalities. It is to be expected that after such an extensive operation, with considerable manipulation around the diaphragm, there would be pulmonary sequelae.

Of all the pulmonary complications, both those causing death and those complicating survival, there were twenty of pulmonary origin, atelectasis being the most frequent. Every effort has been made to forestall this high morbidity and mortality rate, as we have described it in our postoperative care, but it has been our chief cause of trouble.

Peritonitis and formation of abscesses have been the second most serious complications, three deaths (23.1 per cent) having occurred from these causes. Two patients died of generalized peritonitis, subsequent in 1 patient to extension of a subphrenic abscess; in both patients the origin was a fissure at the esophagojejunal anastomosis with leakage. Another death from this source occurred six weeks postoperatively, after the patient had been discharged to his home because of his insistence on release from the hospital.

The third group of operative deaths could be attributed to cardiac failure. The 3 patients, whose deaths constituted 23 per cent of the operative deaths, did not have cardiovascular systems able to withstand the increased demand that this operation places on the heart. None of these patients died in postoperative shock. While most patients were sent back to their rooms in mild shock, all save 1 responded to supportive measures within the first six hours.

Anuria subsequent to the hepatorenal syndrome was the cause of one death.

NONFATAL COMPLICATIONS

As in the case of operative mortality, pulmonary complications are the most frequent cause of postoperative morbidity. The most common trouble was atelectasis, occurring six times; pneumonia or bronchopneumonia developed nine times; pulmonary collapse presented twice, and asthma, mediastinal emphysema and pleural effusion were diagnosed one time each. Cardiac conditions were usually primary causes of death.

Of the abdominal complications, one of the most troublesome has been formation of fistulas. In all this has occurred eight times, though in most instances fistulas have closed in a few days when the Levine tube has been left in place, allowing complete rest of the esophagojejunal stoma. In 1 patient the fistula caused so much subsequent formation of scar tissue that stenosis resulted and a jejunostomy for feeding purposes had to be performed. In 2 other patients bougienage and dilation were necessary to relieve stricture formation. The remainder healed without further complications. There were 2 patients in whom leaks were demonstrated with subsequent localized peritonitis, these subsequently succumbing to subphrenic abscesses. One subdiaphragmatic abscess subsided without treatment. It is therefore apparent that the technical difficulties consequent to anastomosing a wall devoid of serosa is one of the greatest problems in this procedure. This factor, plus the routine presence of virulent organisms in gastric

cancer and the necessity of doing open anastomoses to preserve the already impaired circulation of the distal esophagus, leaves as potential a field for postoperative infection as is found in any procedure in surgery of the gastrointestinal tract.

Serious wound infections occurred in 6 cases, a fact which was not unexpected, but there have been no disruptions of wounds. One of the infections occurred in a patient who died from generalized peritonitis.

In only 1 patient was intermittent severe diarrhea a great problem. It responded to large quantities of dilute hydrochloric acid, as much as 60 cc. being given in divided doses daily through the tube. This is not an uncommon brief and transitory problem during orojejunal feeding, and has always responded well to simple omission of the lactose in the formula and the administration of hydrochloric acid by tube.

Significant postoperative hypoproteinemia has occurred nine times in this series, but in only 4 patients was it difficult to correct with plasma transfusions at frequent intervals, supplementing the high protein feedings. These particular patients had more severe complications as well, which led to their deaths.

Parotitis and pellagra each occurred one time and responded rapidly to appropriate treatment.

METABOLIC AND HEMATOLOGIC ALTERATIONS

It might be expected that after total ablation of the stomach considerable metabolic derangements would result. We have previously noted the frequent reference to a hearty return of appetite after this operation. Harvie [17] as long ago as 1900 reported that his patient within six weeks after the total gastrectomy declared that he "dined happily on roast beef and mashed potatoes."

The greatest disturbance in postoperative metabolic economy is in the absorption of fat. In a previous report [18] from this hospital and these laboratories, metabolic studies on 3 patients who had undergone total gastrectomy were reported, and it was shown that steatorrhea in these patients was related directly to the dietary fat, though possibly related to a fat-sparing action of protein in the diet, and also probably was related to fat-splitting enzymes of the pancreas, to either an insufficiency of these enzymes or improper mixing of the intestinal contents with the pancreatic enzymes. This is not in accord with Farris' [19] finding that complete

17. Harvie, J. B.: Report of a Case of Recovery After Gastrectomy for Carcinoma, Ann. Surg. **31**:344-351, 1900.

18. Rekers, P. E.; Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract: VI. Disorders in Alimentary Digestion and Absorption in Patients Who Have Undergone Total Gastrectomy for Carcinoma of the Stomach, Surgery **14**:197-215, 1943.

19. Farris, J. M.; Ransom, H. K., and Coller, F. A.: Total Gastrectomy: Effects upon Nutrition and Hematopoiesis, Surgery **13**:823-833, 1943.

gastrectomy does not interfere with digestion of fat. It was also shown that this failure to absorb fat was in no way related to lack of gastric chyme or to altered motility of the gastrointestinal tract, or to deficiency of bile salts.

No consistent anomaly of protein metabolism has been noted, but a patient who had a total gastrectomy presented a persistent fecal loss of nitrogen well above the average. This altered metabolism in this patient was related to the amount of dietary protein and also influenced by the intake of fat, since there was a greater creatorrhea with increased ingestion of fat. In 2 patients who had total gastrectomy and in 1 investigated by Farris, no anomaly of protein metabolism was noted. Since metabolic studies on this patient with creatorrhea were done one year after the operation, in contrast to an interval of almost five years in Farris' case, it may be that the functions of protein metabolism may be completely taken over in time by pancreatic trypsin and erepsin of the small intestine.

Farris and his colleagues have shown that absorption of glucose in totally gastrectomized persons is more rapid than normal and results in an early pronounced hyperglycemia which falls rapidly to hypoglycemic levels even by the second hour in glucose tolerance tests, with the lowest levels appearing during the third hour, followed by a slow recovery to fasting levels during the fourth and fifth hours. They attributed these changes to alterations in absorption, utilization or rate of deposit of glucose, because with intravenous glucose tolerance studies, normal curves were obtained. They also showed that these pronounced hypoglycemic levels manifest during the glucose tolerance tests might be the explanation of attacks of weakness, vertigo and palpitation sometimes observed following partial gastrectomy. Five of our patients with symptoms of this type showed normal glucose tolerance reactions.

Six patients subjected to total gastrectomy were studied with respect to the problem of hypoprothrombinemia, and all showed a 22 to 45 per cent drop from preoperative concentrations. It is felt that this hypoprothrombinemia which is somewhat refractory to the parenteral administration of large amounts of vitamin K is most likely on the basis of hepatic dysfunction, and yet this phenomenon does not improve rapidly after gastrectomy.

Three patients who had total gastrectomy manifested a moderate anemia of the normochromic normocytic type; a macrocytic type was not seen in any patient. Studies indicated that the anemia was not due to a deficiency of dietary protein, intrinsic or extrinsic factors or destruction of blood due to infection. Four of Farris' patients survived longer than two years, and none showed evidence of macrocytic anemia. Farris and his co-workers have noted that in some of their patients a hypochromic microcytic anemia of an iron deficiency type developed which

responded to ferrous iron taken one week out of each month. They call attention to the fact that the inorganic iron normally contained in foodstuffs in the ferric form is no longer available for absorption since there is no hydrogen ion to reduce the ferric to the ferrous form for gastrointestinal absorption and that ferrous iron should be given to these patients one week out of every month.

The ablation of such an important organ therefore has a varied affect on metabolic economy. While a few patients undergoing total gastrectomy may gain a little weight, their usual failure to do this is a common complaint. In great part this may be due to their inability to conserve fat. Whether or not this accounts for a consequent loss of fat-soluble vitamins has not been determined, though it has been shown

TABLE 4.—*Survivors of Total Gastrectomy*

Patient	Age	Sex	Involvement of Nodes	Date of Operation	Survival, as of Dec. 1, 1945 (Months)
A. Living and Well					
16. D. G.	52	F	No	5/19/42	42
17. G. W.	60	F	No	5/27/42	42
23. D. E.	58	M	No	8/ 3/43	28
24. E. A.	64	F	No	9/ 3/43	27
30. I. G.	50	M	Yes	6/27/45	5
35. W. C.	47	M	Yes	8/ 1/45	4
36. I. N.	57	F	Yes	10/16/45	1
B. Living with Evidence of Disease					
32. J. M.	63	M	No	1/17/45	10
C. Living After Resections for Benign Lesions *					
39. L. A.	37	F	Noncancerous linitis plastica	1/12/44	23
40. J. R.	43	M	Gastric ulcer	7/24/42	40
41. J. S.	40	M	Gastric ulcer	6/ 1/45	6

* Noncancerous linitis plastica (patient L. A.) and gastric ulcer (patients J. R. and J. S.).

that patients who have had successful resection of cancer of the stomach have a lower incidence of reduced plasma levels of vitamin A than patients in whom cancer of the gastrointestinal tract is still present. Carbohydrate metabolism is apparently less stable, while effects on protein nutrition are not fully indicated. Iron deficiency anemia is to be expected because of the lack of free hydrochloric acid to metabolize the ferric iron, but this is easily treated with ferrous iron. The significance of the continued hypoprothrombinemia is not known.

END RESULTS OF TOTAL GASTRECTOMY

Of the 11 patients still living after this operation on Dec. 1, 1945, 1 has evidence of recurrence of his cancer (table 4). Seven patients who had resections for carcinoma have no evidence of recurrence (figs. 10 and 11), and 3, who had the operation for benign lesions, are asymptomatic. In the series for cancer, there are 5 patients who survived

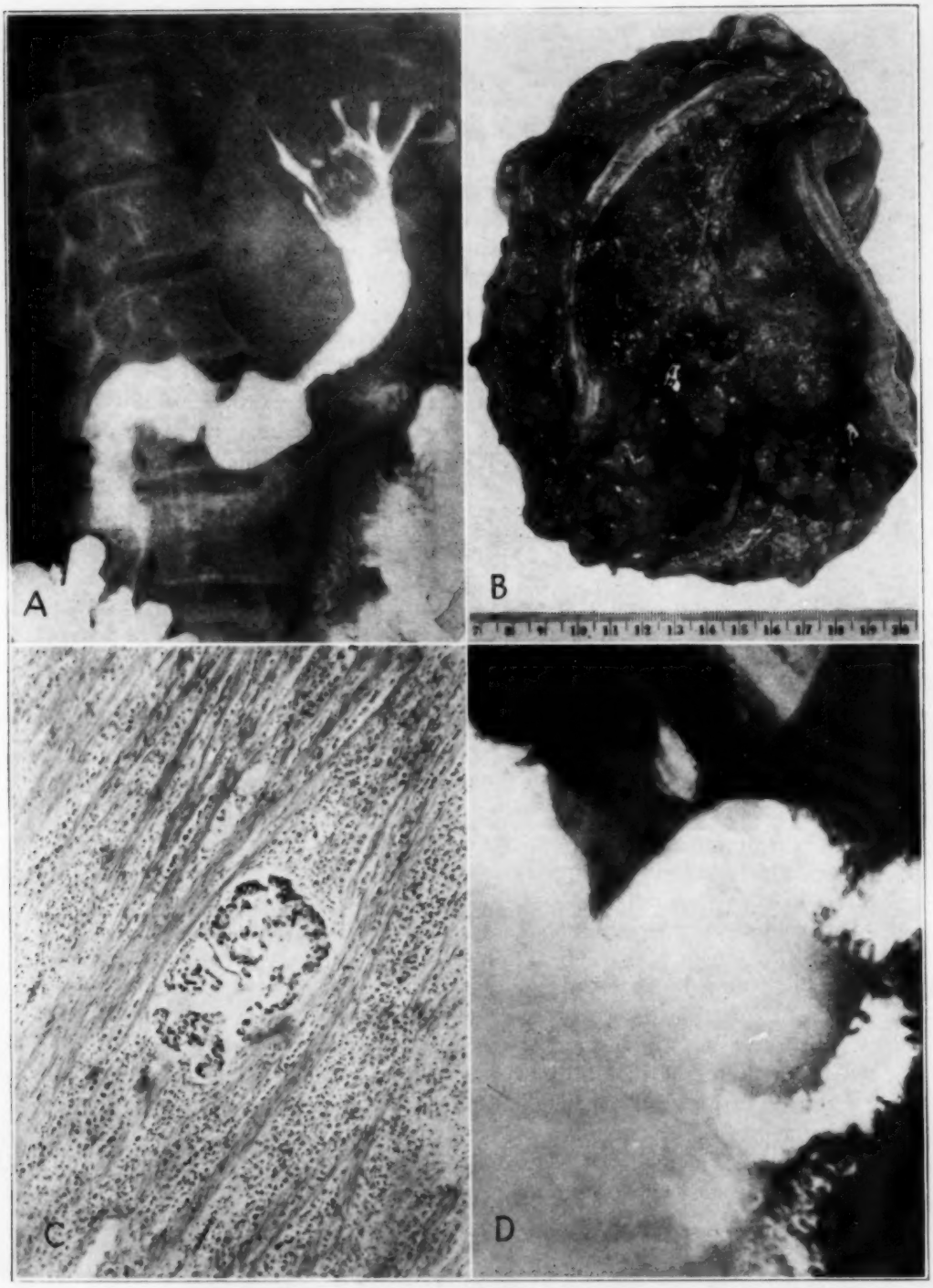

Fig. 10.—Patient E. A., a 64 year old woman, had symptoms of "indigestion" for eight months. *A*, preoperative roentgenogram showing marked contraction of the middle third and, to a lesser extent, the upper third of the stomach. *B*, gross pathologic specimen after opening it along the greater curvature of the stomach. Almost the entire stomach is involved with tumor which infiltrates the entire thickness of the gastric wall. *C*, photomicrophotograph showing an adenocarcinoma of varied structure from purely glandular to diffuse gelatinous to cellular signet pattern. × approximately 195. *D*, gastrointestinal roentgenogram twenty-seven months after operation, showing smooth contour of the distal part of the esophagus and normal mucosal pattern of jejunum.

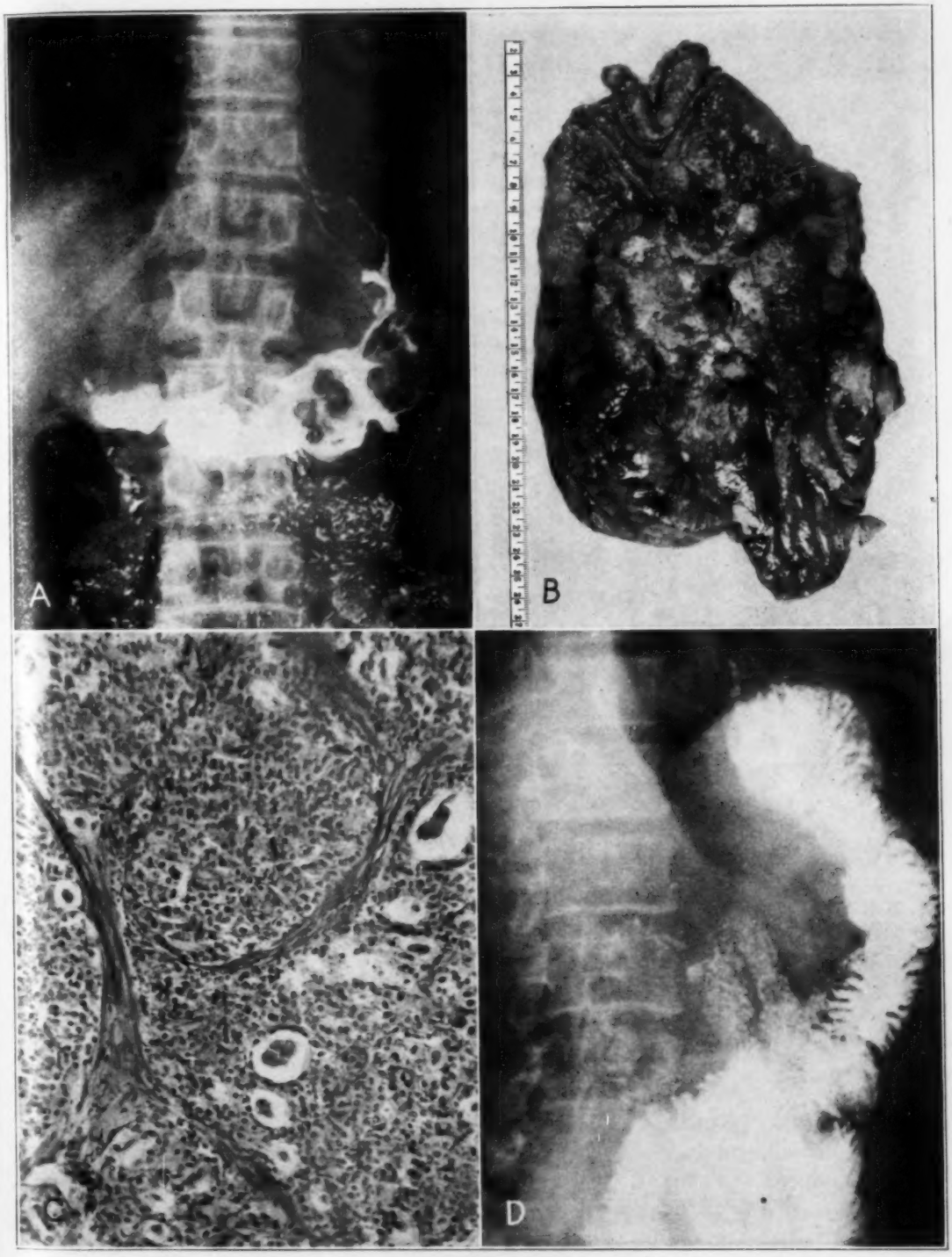

Fig. 11.—Patient D. E., a 58 year old man, had symptoms of one year's duration. *A*, preoperative roentgenogram showing extensive filling defects extending to both the pyloric and the cardiac portion of the stomach. *B*, opened resected specimen showing extensive ulceration with overhanging polypoid margin. *C*, photomicrograph showing an adenocarcinoma of grade III histologic malignancy. There was penetration of the wall and direct extension to lesser omentum. × approximately 205. *D*, gastrointestinal roentgenogram thirty-two months after operation. There is mild dilatation of the jejunum to form a small pouch.

more than three years, the longest surviving three years and seven and one-half months. All these presented no evidence of extension to tributary lymph nodes at the time of operation. One patient whose ulcer was resected has survived over three years and four months and has no complaints except that after eating a big meal he has a sensation of fulness so that he prefers to eat four or five smaller meals per day

TABLE 5.—*Cause of Death of Survivors of Total Gastrectomy: A. Detailed Case Reports*

Patient	Age	Sex	Involvement of Nodes	Date of Operation	Survival in Months	Condition at the Time of Last Examination or at Time of Death
1. M. B.	59	M	Yes	8/21/33	1.5	Subphrenic abscess
2. D. S.	42	F	No	11/ 9/38	26	Bone metastases
5. J. C.	54	M	No	3/26/40	17	Hepatic metastases
6. L. S.	62	F	Yes	7/ 2/40	8	Recurrence
7. A. Z.	59	M	No	8/13/40	43.5	Metastases in hernia and cul-de-sac
8. F. B.	61	M	No	9/10/40	10.5	Hepatic metastases
10. E. F.	55	M	No	7/ 2/41	42	Possible recurrence
11. F. B.	46	M	Yes	11/ 7/41*	23	No information
12. L. R.	55	F	No	2/31/42	23.5	No evidence of disease; accidental death
14. E. L.	65	F	Yes	5/ 6/42*	24	Recurrence near scar
15. C. W.	46	F	No	5/13/42	36	No information
20. E. W.	46	M	No	2/ 1/43	12	Recurrence and metastasis to liver at nine months postoperatively
21. H. G.	46	M	Yes	2/ 3/43	8.5	Metastases to liver and pelvic deposits
22. M. L.	55	M	Yes	5/ 5/43	5.5	No information
25. I. K.	42	F	Yes	4/24/44	10	Nodule in scar and large pelvic mass
28. S. G.	58	M	Yes	8/18/44	9	Epigastric masses and deposits in cul-de-sac
31. C. S.	30	M	Yes	10/../44	3	Multiple metastases

* Palliative resection.

TABLE 6.—*Cause of Death of Survivors of Total Gastrectomy: B. Summary*

Cause of Death	Total Cases	Nodes Involved	Nodes Not Involved
Total cases	17	9	8
Metastases	8	4	4
Recurrence	3	2	1
Metastases and recurrence	1	..	1
Subphrenic abscess	1	1	..
No information as to condition at time of death	3	2	1
No evidence of disease; accidental death	1	..	1
Average survival in months	17.8	10.3	26.3

(fig. 3). Three patients are living postoperatively less than six months, but all had lymph node metastases and a good prognosis cannot be offered to them.

The 17 patients who survived the operation, but died subsequently, lived an average of eighteen months. Of this group there is no information as to the cause of death of 2 and 1 died an accidental death two years after her operation. The remaining 14 died of their original cancer.

Nine of the patients in whom extension of the cancer to the regional lymph nodes was found at the time of operation survived an average

of only ten months, as compared with the results in 8 patients with no lymphatic extension to surrounding lymph nodes who survived an average duration of twenty-six months (table 6).

SUMMARY

A series of forty-one total gastrectomies is presented, forty of which were done by the abdominal route. There were thirteen operative deaths, a mortality rate of 31.7 per cent. Seventeen patients survived an average of eighteen months; 8 of these without nodal involvement at the time of operation averaged twenty-six and three-tenths months.

There are 11 patients surviving total gastrectomy; 7 operated on for cancer are living and well, although 3 were operated on less than three months ago, and 3 operated on for benign lesions have survived from six months to three years and four months. Five of 37 patients who had total gastrectomy for cancer of the stomach survived or are living over three years, an average of 13.6 per cent.

Total ablation of the stomach has been attended by surprisingly little alteration in nutrition.

A 13.6 per cent three year survival rate for extensive cancer of the stomach marks progress in the treatment of a disease too generally considered hopeless.

DECORTICATION IN THE TREATMENT OF CHRONIC EMPYEMA

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AND
JOSEPH W. GALE, M.D.
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IN CHRONIC empyema the deposition of fibrous tissue on the pleural surfaces results in an immobile, unyielding and nonexpansile lung. This problem has confronted and baffled physicians since the time of Hippocrates. It was not until the nineteenth century, with the introduction of anesthesia, antisepsis, and later roentgen ray, that any definite effort was made to cope with this debilitating condition. Letievant,[1] in 1860, and later Simon, in 1869, suggested multiple rib resection. It remained for Estlander [2] in 1879 to popularize this procedure. They rationalized that if a lung failed to meet the chest wall, then the chest wall must be collapsed to meet the lung. Schede [3] pointed out in 1890 that not infrequently the thick, stiff pleura did not permit the chest wall to collapse following thoracoplasty. He overcame this obstacle by removing the parietal pleura, intercostal bundles, and ribs overlying the empyema space—so-called cavity unroofing.

Four years later Delorme [4] realized that while thoracoplasty accomplished its objective by obliterating the pleural space, it also produced marked anatomic deformity, and physiologically was not ideal because of the reduction in pulmonary function. He advocated a decortication of the binding scar from the visceral pleura. Theoretically the idea was sound, but surgical knowledge was insufficiently advanced in 1894 to execute this procedure successfully. The high mortality, frequency of complications and the moderate number of cures left much to be

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From the Department of Surgery, University of Wisconsin Medical School.

Read by title at the fourth annual meeting of the Central Surgical Association, Chicago, Feb. 21, 1947.

1. Letievant, cited by Murphy, J. B.: Surgery of the Lung, J.A.M.A. **31**:151 (July 23) 1898.

2. Estlander, J. A.: De l'influence du traitement antiseptique sur la mortalité des plaies de la téte, Nord. med. Ark. **11**:1, 1879.

3. Schede, M.: Die Behandlung der Empyeme, Verhandl. d. Cong. f. inn. Med. **9**:41, 1890.

4. Delorme, E.: Nouveau traitement des empyemes chroniques, Gaz. d'hôp. **67**:94, 1894.

desired, and the procedure was soon abandoned. Modifications of this operation, such as Ransohoff's gridiron incisions dividing the visceral scar, met with indifferent success.

During World War I Graham [5] brought out in bold relief the fact that many rigid and unyielding lungs would expand sufficiently to obliterate the pleural space if the empyema cavity were drained dependently and adequately and irrigated with dilute solution of sodium hypochlorite, N. F., to produce fibrinolysis. In recent years continuous negative suction has been added to this regimen, making possible rapid reexpansion of the lung. Nevertheless, a small group of cases remained in which the lung failed to expand completely and required a thoracoplasty or unroofing operation.

In World War II Churchill [6] and his thoracic teams in the European theater were confronted with numerous hemothoraxes and pyohemothoraxes with nonexpansile lung. Thoracoplasty in these otherwise normal persons would most certainly lead to permanent semi-invalidism. They met this challenge by reconsidering Delorme's decortication. The time was now ripe for a real trial of this approach to the problem. Well trained thoracic surgical teams, antibiotics and blood resulted in a low mortality and a minimum of complications. The number of cures was remarkably high. They concluded that the optimum time for surgery is within six weeks following the injury. Subsequently, because of increasing fibrosis, it becomes progressively more difficult to remove the membrane or peel. In acute cases it is only necessary to remove completely the peel from the visceral pleura.

At the meeting of the American Association for Thoracic Surgery in 1946, Tuttle suggested the use of decortication in acute pyogenic empyema, and Gurd reported 3 cases in old tuberculous empyema with fair to poor results.

REPORT OF CASES

We shall present 2 cases of chronic pleuritis successfully treated by decortication.

CASE 1.—A white man 43 years old was admitted to the Wisconsin General Hospital in July 1946. In November 1945 pneumonia developed secondary to exposure to cold and rain. Hospitalization for nine days and antibiotic therapy incompletely relieved his symptoms. In January a recrudescence of symptoms with increasing dyspnea, night sweats, weakness, and loss of weight forced his return to the hospital, where he remained for forty-three days. A diagnosis of pleurisy was made. Several pleural aspirations revealed straw-colored fluid. Studies of this fluid, sputum and gastric washings were negative for tubercle

5. Graham, E. A.: Fundamental Considerations in the Treatment of Empyema Thoracis, St. Louis, C. V. Mosby Company, 1925.

6. Churchill, E. D.: Trends and Practices in Thoracic Surgery in the Mediterranean Theatre. J. Thoracic Surg. **43**:307, 1944.

bacilli. The local physician induced and maintained pneumothorax. Since the patient's condition was progressively becoming worse, he was advised to vacation in Tucson, Arizona, where no improvement was noted. At the time of admission to this hospital he was unable to climb a flight of stairs without dyspnea, palpitation and vertigo. A loss in weight of 45 pounds (20.4 Kg.) had occurred, and

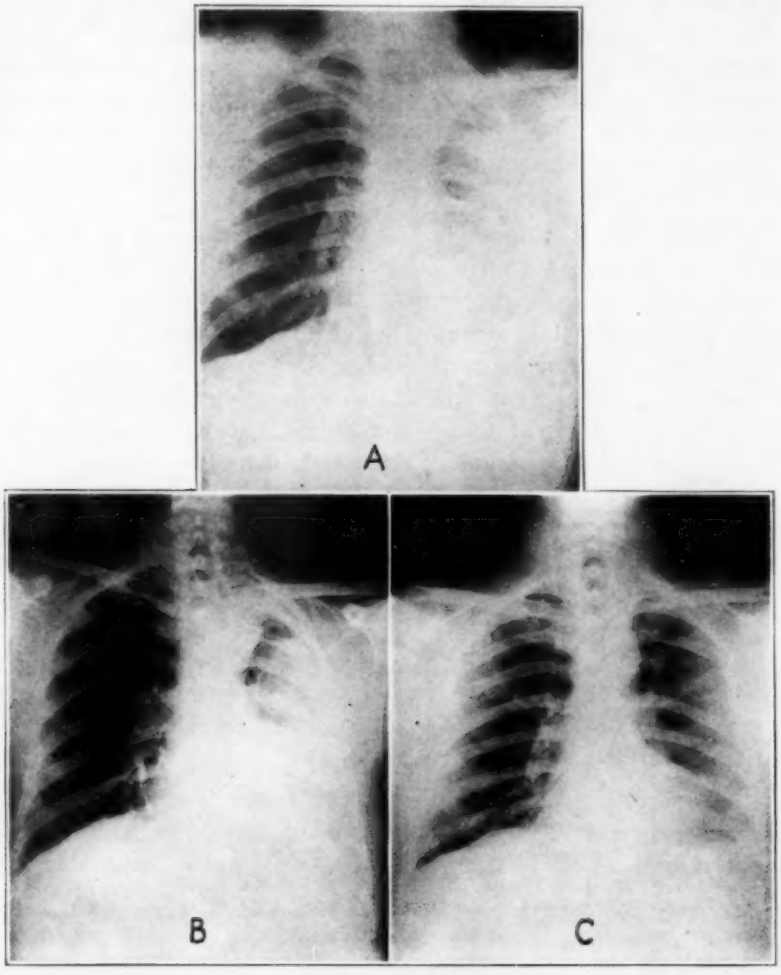

Fig. 1 (case 1).—*A*, this roentgenogram shows marked thickening of the left pleura, a small amount of fluid, narrowing of the left interspaces and elevation of the left side of the diaphragm. *B*, roentgenogram taken five months later shows complete expansion of the chest wall. *C*, one year later with further clearing of pleuritis.

the patient no longer was able to conduct his business as a contractor. There was no history of cough or expectoration. Examination revealed a marked decrease in size of the left side of the chest and no motion on deep inspiration. Vibratory phenomena were absent on the involved side. Roentgen rays (fig. 1*A*) showed

marked thickening of the left pleura, a small amount of fluid, narrowing of the left interspaces, and an elevation of the left side of the diaphragm. A bronchogram did not reveal bronchiectasis or obstruction, and the underlying lung appeared to be free of pathologic change.

In view of the negative bacteriologic studies and absence of pulmonary lesions, decortication was carried out on July 20, 1946. The peel or pyogenic scar varied from ½ to 1 inch (1.27 to 2.54 cm.) in thickness. Some difficulty was encountered in its removal, and at several points a small amount of visceral pleura was torn. The lung expanded readily, but much to our consternation we noted its volume was much greater than that of the left thoracic cage. Indeed, on complete expansion the lung herniated well outside of the contracted and fixed chest wall. In order to mobilize and expand the wall, it was decided to remove the peel from the parietal and mediastinal pleura as well. This was accomplished, and the enlarged pleural space now held the fully expanded lung. Postoperatively continuous negative suction was applied. Convalescence was uneventful, and the

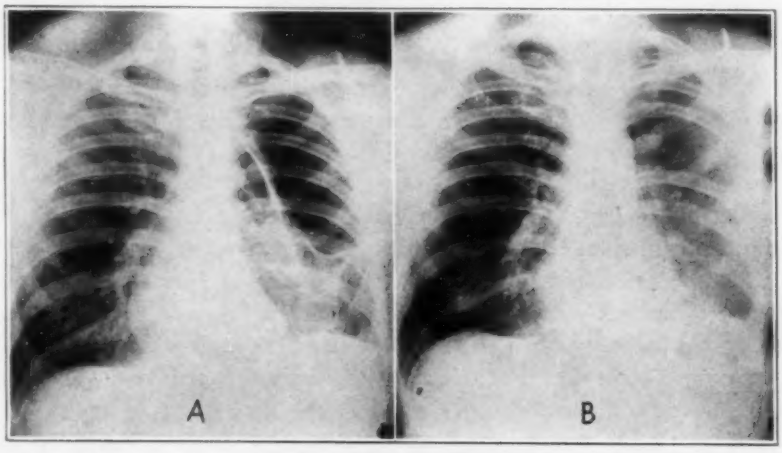

Fig. 2 (case 2).—*A*, the roentgenogram shows a wide pneumothorax space with compression of the underlying lung. *B*, there is complete expansion of the lung four weeks after discharge from hospital.

patient was discharged on the twelfth postoperative day. Figure 1*B*, a roentgenogram taken five months later, shows complete expansion and excellent motion of the chest wall. In a recent check-up (fig. 1 *C*) the patient stated that he was able to carry on all business activities and had regained his normal weight and strength.

Case 2.—A 42 year old white man was admitted to the Wisconsin General Hospital on Oct. 23, 1946, with a chief complaint of "pus in the chest." He dated the onset of his illness to July 23, 1946, when he suffered a thoracic gunshot wound, which was followed by a pyohemothorax. Tube drainage and irrigations at a local hospital controlled the infection, but the lung became fixed and nonexpansile. At the time of admission the patient did not appear acutely ill. A tube drain was present in the ninth interspace at the posterior axillary line. Thoracic signs were compatible with those of a pneumothorax on the left side. Fluoroscopy revealed little if any movement of the left lung on respiration. Roentgen rays (fig. 2 *A*) demonstrated a wide pneumothorax space with compression of the under-

lying lung. Continuous negative suction was unsuccessful in expanding the lung. On Nov. 20, 1946, four months after the initial trauma, decortication was performed. A cleavage plane between the pyogenic membrane and the lung was readily found and the peel removed from the visceral and parietal pleuras. The lung was completely expanded and the chest closed. Continuous intrapleural negative suction of —14 cm. of water was maintained for three days. The postoperative course was uneventful, and the patient was discharged ten days after his operation. Figure *2B* shows complete expansion of the lung four weeks after discharge.

The goal of an ideal surgical procedure is to correct adequately the pathologic condition but at the same time to maintain normal function and anatomic relationships. Thoracoplasty achieves the first objective but fails completely in fulfilling the remainder. When successful, decortication preserves the chest wall and permits a physiologic restoration of pulmonary function. Therefore, in the treatment of acute and chronic pleural effusions, decortication would appear as the operation of choice. The only exception would be a certain group of tuberculous empyemas, which will be discussed later.

Our 2 cases presented two problems not ordinarily seen in acute or early cases of inexpansile lungs. In chronic effusions it is necessary to remove the parietal, mediastinal and possibly the diaphragmatic pleuras as well as the visceral pleura. Nature in attempting to obliterate the pleural space shingles the ribs on one another, draws the mediastinum to the involved side, elevates the diaphragm and splints the thoracic cage by the application of a heavy scar on the parietal pleura. These compensatory changes produce (1) a small pleural space and (2) a fixed, functionless chest wall. The restoration of a normal anatomic relationship and function can be accomplished only by the removal of the binding scar from the thoracic cage.

These 2 cases demonstrate a relationship between ease of dissection and the chronicity of infection. In the second case, of four months' duration, the cleavage plane was readily found and the pyogenic membrane removed without undue trouble. In the first case the effusion was of seven months' duration, and the membrane and visceral pleura were difficult to separate at various points because of their intimate attachment. The pleura was torn at these points, and air leaked on full expansion. It is imperative in such instances to maintain full expansion by continuous negative suction. Failure to do this may result in pulmonary collapse and recurrence of the original lesion.

Besides chronicity of the effusion, the type of inflammatory exudate may influence the amount and extent of adherence of the inflammatory membrane. In effusions in which polymorphonuclear exudation predominates, fibrin is deposited on the pleura. There is later replacement by fibrous tissue although the fibrin is lysed by fibrinolysins released by destroyed polymorphonuclear white blood cells. This action may aid

in maintaining a cleavage plane between the lung and membrane. In lymphocytic effusions practically no fibrin is laid down, and there is formation of fibrous tissue directly on the visceral pleura. This may be the reason why there is greater difficulty in obtaining and maintaining a cleavage plane in this type of infection.

Previously we mentioned the possible application of decortication in tuberculous empyema. This type of effusion introduces the added factor of pulmonary tuberculosis, which must be considered before this surgical procedure can be entertained. It is important to know the extent of pathologic change in the underlying pulmonary tissue and bronchi. Obviously, if both lobes are involved decortication is useless

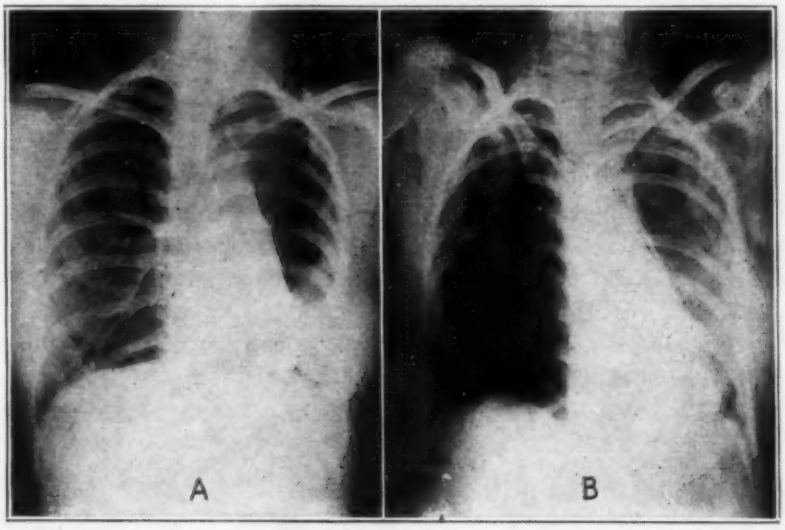

Fig. 3 (case 3).—*A*, entire side shows a tuberculous process. *B*, appearance after pneumonectomy.

unless it is followed by immediate complete thoracoplasty. In the presence of tuberculous bronchitis or stenosis, reexpansion by decortication may reactivate the disease or may produce shifting of the mediastinum with overexpansion of the apparently contralateral lung. It is our opinion that decortication for tuberculous empyema with nonexpansile lung should be reserved solely for those cases of disease limited to the upper lobe and with no evidence of tuberculous bronchitis. In such cases decortication following thoracoplasty of the upper part of the chest would collapse the diseased lobe and retain good function in the apparently healthy lobe.

Case 3.—A 22 year old woman recently admitted to the Wisconsin General Hospital best illustrates most of the preceding points. Pneumothorax induced in June 1945 was complicated by an effusion and inexpansile lung. Efforts to

reexpand the lung were fruitless. Sputum continued to be positive for acid-fast organisms. The effusion at no time showed bacteria. Bronchoscopy shortly after admission demonstrated no evidence of acid-fast bronchitis. Ordinarily, a complete thoracoplasty would have been our first choice. However, in the hope that the lesions might be limited to the upper lobe we strongly considered decortication and thoracoplasty of the upper part of the chest. On receiving her original films (fig. 3*A*) it was noted that the entire side had been extensively involved in a tuberculous process. Our choice now was: (1) complete thoracoplasty and aspirations of the pleural cavity, (2) decortication, pulmonary reexpansion, and thoracoplasty or (3) pneumonectomy and complete thoracoplasty. Since the effusion never showed organisms, we elected pneumonectomy (fig. 3*B*), which was shortly followed by thoracoplasty. In preferring this method of procedure we assumed a slight risk of an acid-fast empyema in the residual pleural space in the future.

CONCLUSIONS

Reexpansion by decortication of chronic nontuberculous inexpansile lungs is feasible.

In chronic effusions it is usually necessary to remove the parietal pleura and occasionally the mediastinal pleura as well as the visceral pleura.

Intrapleural continuous negative suction is an important aid in maintaining expansion, particularly if the visceral pleura is injured.

The type of inflammatory exudate may influence the ease with which decortication is performed.

In certain selected cases of tuberculous empyema decortication and thoracoplasty would appear to be of value.

ENDOTRACHEAL ANESTHESIA

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MODERN endotracheal anesthesia is a technic in which the administration of an anesthetic may be facilitated and the patient benefited by an artificial extension of the tracheobronchial tree by means of a tube through which the patient's respiratory exchange takes place. Endotracheal tubes are made of materials such as rubber and plastic. When in place these tubes create a relatively nonobstructable channel through which the respiratory exchange occurs.

Basically, an endotracheal technic is one in which a tube is passed through the mouth (constituting an orotracheal intubation), through the nose (constituting a nasotracheal intubation) or through a tracheostomy opening (constituting a tracheostial intubation). Intubation may be performed under direct vision by the use of a laryngoscope or by the so-called "blind" technic, the tube being maneuvered through the glottis by skilful manipulations. Successful intubation requires considerable practice and a good knowledge of the structure and the functions of the upper respiratory passages.

The competent anesthesiologist must be a master of both technics, prepared to use whichever is indicated in any given situation. There are patients in whom pathologic conditions of the mouth or throat render visualization of the larynx impossible or extremely difficult, and blind intubation is essential. Conversely, there are circumstances which make direct intubation the method of choice.

If an airtight system is required, it may be achieved by including an inflatable rubber cuff around the tube to make tight contact with the trachea. Similar results may be accomplished by the use of a pack. This pack usually consists of a half inch (1.27 cm.) gauze roll which

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has been impregnated with liquid petrolatum. This gauze is then firmly packed around the endotracheal tube above the laryngeal orifice. This seals the pharynx from the respiratory passages, thus preventing foreign material from getting into the respiratory passages.

Many advantages are derived from the use of the endotracheal technics, but basically they may be classified in five main groups.

ADVANTAGES OF ENDOTROCHEAL TECHNIC

1. The first group of advantages are those which result from the free and relatively nonobstructable airway.

Many of the most distressing difficulties encountered during general anesthesia result from respiratory obstruction, due frequently to falling back of the tongue or intractable laryngospasm. Such complications endanger the patient's welfare and his life. They also may seriously hamper the surgeon in the performance of an abdominal operation by causing straining and exaggerated respiratory movements. Endotracheal anesthesia obviates these difficulties.

As a result of the tube being placed in the larynx, one has to all intents and purposes eliminated the grunting reflex by removing one of its components, the adduction of the cords. The grunting reflex, therefore, will not be seen in patients who are intubated.

One of the original reasons for the development of endotracheal anesthesia was to facilitate operations on patients partially obstructed by masses encroaching on the respiratory passages. As a result of the relative nonobstructability of the endotracheal tube, these masses do not cause obstruction. Thus one creates a clear respiratory passage in spite of such lesions as large carcinomas of the tongue, pharynx, thyroid, larynx and other organs.

An endotracheal tube may be left in place postoperatively when it is anticipated that swelling will occur under rather firm dressings, with a possibility of obstruction of the respiratory passages. The tube then remains in place until such time as the fear of edema has passed. This is applicable in cases in which are performed such procedures as mandiblectomy, bilateral radical cervical dissections and similar operations in which firm dressings are desirable and in which extensive procedures have been performed in the region of the respiratory passages.

The patient who is partially obstructed preoperatively owing to masses or edema in the area of the pharynx or larynx may become completely obstructed when consciousness is lost as a result of general anesthesia. It is, therefore, necessary in some instances to intubate these patients under topical anesthesia prior to the commencement of general anesthesia. Once the tube is in place, this patient has a better airway than was present before.

As a preliminary to tracheostomy intubation can relieve the urgency of the situation and permit the surgeon to proceed calmly and judiciously while the patient remains well oxygenated. In some instances of temporary obstruction, intubation may be substituted for an otherwise unavoidable tracheostomy.

2. The second group of advantages are those resulting from the fact that the hands and apparatus of the anesthetist may be removed from the head area, leaving the surgeon a clear operative field. Thus one is able to do such operations as those on the mouth, tongue, palate, jaw and face with nothing more than a small rubber tube in some portion of the operative field. This can be adequately draped so that the surgeon may have a relatively sterile field.

3. The third group of advantages are those resulting from the ease with which control of respiration and artificial respiration may be accomplished.

Artificial respiration may be easily accomplished by mere manual pressure on the breathing bag or by blowing down the tube. The possibilities of failure to inflate the lungs due to obstruction or of inflating the stomach are avoided.

With endotracheal anesthesia one is able to supplement the respiration of those who, owing to various and sundry factors such as general debility, open chest, diseases of the lungs, toxic or drug depression, have a diminished respiratory exchange. By gentle pressure on the breathing bag as these patients inhale one is able to increase the amplitude of the inspiration, thus producing better aeration of an otherwise hypoxic patient.

A further development is "controlled respiration," a method whereby spontaneous respirations are eliminated and inflation of the lungs is carried out by the anesthesiologist and timed to give the surgeon the optimum working conditions.

4. The fourth group of advantages are those that result from the elimination of the danger of aspiration of debris, blood, pus and vomitus.

These benefits are important to those who operate on patients who have lesions of the upper respiratory tract and pharynx. In an emergency case of almost any type there may be a full stomach. It is best that the food be removed when possible and, in addition, an endotracheal tube with a cuff be used so that the vomitus will not find access to the tracheobronchial tree.

Patients with dilated gastrointestinal tracts frequently regurgitate some of the contents into the pharynx without any visible evidence of vomiting. This silent vomiting would be extremely damaging if the vomitus were aspirated. Thus again the tube with the cuff gives one the assurance of a noncontaminated airway.

5. The fifth group of benefits derived from this technic is that removal of material from the treacheobronchial tree may be accomplished with ease by inserting a suction catheter through the tube.

This aspiration may be accomplished before, during or after the operative procedure. The patients most frequently requiring this bronchial aspiration are those who suffer from such conditions as pulmonary abscesses, bronchiectasis, tuberculosis and chronic bronchitis.

In many instances this technic of endobronchial aspiration may be used to treat postoperative atelectasis. It definitely does not have the certainty connected with direct visual bronchoscopic aspiration but is in many cases successful. It is usually accomplished by passing a tube with the use of topical anesthesia. This technic in the hands of those skilled in its use has the advantages of ease and speed of accomplishment. Yet, should this fail, no time should be lost in requesting a bronchoscopic aspiration.

DISADVANTAGES OF TECHNIC

Endotracheal anesthesia is not without its hazards and dangers. First among these dangers is trauma. The trauma most frequently encountered is contusion of the mucosa due to some difficulty in intubation. It is rarely severe or lasting and usually takes the form of a complaint of hoarseness or mild cough for the first day or two postoperatively. Children are most susceptible to trauma owing to the smallness of the laryngeal orifice. Another factor of considerable importance is that the submucosa is made up of loose areolar tissue which easily becomes edematous. The danger of edema of the larynx in children who have been intubated must be kept in mind; yet it is rarely seen.

Trauma as a result of allowing the tube to remain in place for long periods is not frequently encountered. In one instance a tube remained in place five consecutive days without being changed. The patient died of other causes and sections of the larynx failed to show any evidence of damage other than a slight round cell infiltration.

Bleeding is also seen as a result of attempting this technic. Most frequently it results from attempts at nasal intubation. Bleeding is rarely severe or prolonged. Another danger is that of endobronchial intubation as a result of the use of a tube that is too long. This will result in a massive atelectasis of the side opposite that in which endobronchial intubation has been performed. This complication can quickly be corrected by withdrawing the tube.

All of the dangers or hazards enumerated markedly diminish as the skill of the anesthetist increases.

SUMMARY

Thus, in summary, one might state that endotracheal anesthesia has much to offer the patient, the surgeon and the anesthesiologist. This technic diminishes many of the dangers of surgical procedures, facilitates the ease with which the surgeon may operate and renders more easily accomplishable the mission of the anesthesiologist, which is the guarding of the safety of the patient while at the same time aiding and facilitating the surgeon's activity. This technic, good in the hands of the competent anesthesiologist, has hazards which increase tremendously in the hands of the incompetent.

A DOUBLE-LUMENED PLASTIC TUBE FOR INTESTINAL INTUBATION

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WYANDOTTE, MICH.
AND
HOMER M. SMATHERS, M.D.
DETROIT

DECOMPRESSION of the small bowel by intestinal intubation is now a well established surgical principle. Many persons, while recognizing the value of this procedure, have experienced difficulties in the passage of the tube beyond the pylorus and in maintaining adequate suction. It has therefore seemed worth while to develop a type of tube which can be more easily passed even in the hands of those using the procedure only occasionally. A good general discussion of the problems associated with the technic of intestinal intubation has been presented by Johnston.[1]

Abbott and Johnston [2] in the first article to appear on the use of intubation of the small bowel in obstruction, emphasized that "the ideal tube should have two lumina, one very large for the aspiration of intestinal content and one very small for the introduction of air into the balloon." Other criteria for the ideal intestinal tube are that it should be flexible enough to follow the contour of the bowel easily yet rigid enough to prevent kinking and not to collapse on suction. It must be nontoxic, opaque to fluoroscopy and easily introduced into the gastrointestinal tract. Various types of tubes now on the market have been investigated, and none has fulfilled all these requirements. Further, these tubes are of rubber, and in recent years good tubing has been difficult to obtain besides being costly.

Plastic tubing appeared to us to offer certain advantages, and during the past two years we have used various types of tubing made from this substance. The tube presently in use fulfils all the requirements men-

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From the surgical services of the Detroit Receiving Hospital and the Wyandotte General Hospital and the Department of Surgical Research, Wayne University College of Medicine.

1. Johnston, C. G.: The Technic of Intestinal Intubation, in Nelson Loose Leaf Surgery, New York, Thos. Nelson & Sons, 1927, pp. 651-662.

2. Abbott, W. O., and Johnston, C. G.: Intubation Studies of the Human Small Intestine: X. A Non-Surgical Method of Treating, Localizing and Diagnosing the Nature of Obstructive Lesions, Surg., Gynec. & Obst. **66**:691-697 (April) 1938.

tioned, withstands boiling without rapid deterioration and has the further advantage that intestinal odors are readily removed by washing.[3] The tubing is made of a plastic, Geon polyvinyl chloride, impregnated with a nontoxic radiopaque material. The large lumen for suction has a bore equivalent to that of a no. 16 French tube. The wall is slightly thinner than that of the Miller-Abbott or the Jutte tubing. The smaller tube has a lumen which just admits an 18 gage needle. The two tubes are extruded at once into a double tube unit having a smooth contour. The relative size and contour of this tube as compared with others generally in use are presented in figure 1. With this plastic tube we have combined the principle of an inflatable balloon, first suggested by Miller and Abbott,[4] and that of the use of mercury in this balloon, a principle first suggested by Harris [5] and Wilkins.[6] The tube ready for use is shown in figure 2.

Several types of intestinal tubes with many modifications have been studied since April of 1945. These include: (*a*) the Miller-Abbott tube,[7] with and without mercury in the balloon, with the balloon either proximal or distal to the end of the tubing; (*b*) the Johnston tube [1]

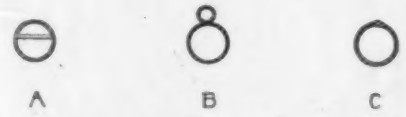

Fig. 1.—*A*, cross section of the Miller-Abbott tube. *B*, cross section of the Johnston tube. *C*, cross section of the new plastic tube.

with and without the addition of mercury in the balloon, with the balloon proximal or distal to the end of the tubing; (*c*) the single-lumened rubber tube with the balloon containing mercury leading the tube into the bowel; (*d*) single-lumened rubber tubes with metal weights of various size and shapes attached at various distances from the end of the tubing; (*e*) single-lumened tubes with metal weights in tandem arrangement attached to the end of the tube, and (*f*) single-lumened and double-lumened plastic tubing with the balloon either proximal or distal to the end of the tube.

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3. The plastic compound is made by the B. F. Goodrich Chemical Co., Cleveland. The tubing is made by Jessall Plastics, Hartford, Conn.

4. Miller, T. G., and Abbott, W. O.: Intestinal Intubation: A Practical Technique, Am. J. M. Sc. **187**:595-599 (May) 1931.

5. Harris, F. I.: A New Rapid Method of Intubation with the Miller-Abbott Tube, J. A. M. A. **125**:784-785 (July 15) 1944; correction, ibid. **126**:718 (Nov.11) 1944.

6. Wilkins, J. A.: Mercury-Weighted Stomach Tube, J. A. M. A. **91**:395-396 (Aug. 11) 1928.

7. Abbott and Johnston.[2] Harris.[5]

Whenever double-lumened tubing was used, trials were made both with mercury and air combined and with air alone in the balloon. The effect of varying the quantity of mercury was also tested.

Certain difficulties have been encountered during the use of these various tubes in the treatment of 240 patients with intestinal obstruction. Most noticeable was the plugging of the lumen of the Miller-Abbott tube by particulate matter. This was seen on many occasions and required frequent irrigations in order to keep the lumen open. The Johnston tube takes considerable time to assemble, and the two tubes when placed together seemed unduly large for the average patient's nares. The use of various solid weights leading the long tube was abandoned because of slow and uncertain passage at or just beyond the ligament of Treitz.

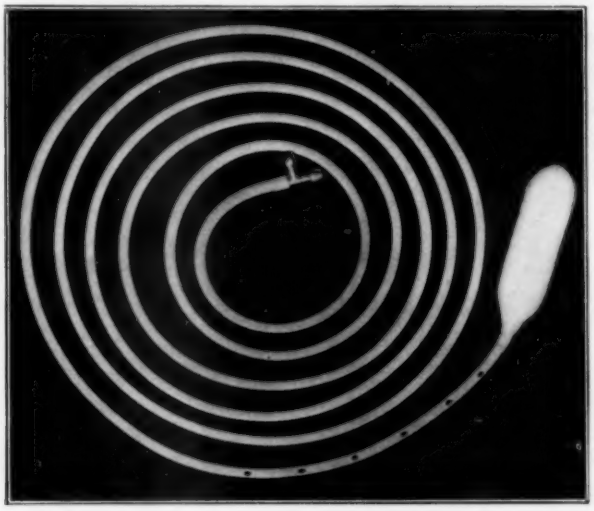

Fig. 2.—The plastic tube.

Olive or round-shaped weights could be passed through the pylorus readily, but frequently the tubing would be advanced ahead of the weight in the third portion of the duodenum or in the jejunum, and the dragging metal behaved much like an anchor.

The efficacy of the double-lumened tube has often been seriously questioned. Our observations have proved beyond a doubt that the double-lumened tube is highly preferable to the single-lumened one. The chief difficulty with the single-lumened tube with mercury is the inability to control it once it has passed into the small bowel. Inability to inflate the balloon requires that the tube progress almost entirely by the weight of the mercury, because the diameter of the balloon is too small for the bowel to obtain adequate purchase for peristalsis. In our experience the slowest passage of the single-lumened tube occurred in cases of tre-

mendous dilatation of the small bowel, in which the need for rapid decompression was greatest. With the double-lumened tube, the balloon can be inflated when it reaches distended bowel, and peristalsis rapidly carries the larger object forward. The reason for this will be apparent from a study of figure 3.

Several technics for intestinal intubation have been reported.[8] It should be emphasized that no one type of procedure will adapt itself to all patients. The patient's condition frequently dictates caution rather than an overzealous effort at manipulation on the fluoroscopic table. In general, our method for passage of a long tube is as follows: After instilling a 1 per cent solution of tetracaine hydrochloride, butacaine sulfate or any other mild local anesthetic agent into the nostrils by drops or spray, the tube lubricated with petrolatum and with the balloon containing 2 cc. of mercury is inserted through the nostril with the patient supine. A curved hemostat, stylet, or forceps may be used to aid in this step.

Fig. 3.—*A*, distended small bowel with mercury-weighted tube. *B*, distended small bowel with inflated balloon and mercury.

With the mercury in the balloon pulling the tube into the pharynx, the patient is instructed to sit up and swallow. The tube then drops rapidly into the stomach. If the patient can safely be transported, the use of a fluoroscopic table will greatly facilitate the procedure, as the position of the balloon can be checked by fluoroscopy. If the tube is passing toward the pylorus, slack is given and the patient is turned on the right side. When the balloon is at the pylorus, the head of the table is elevated in order that the tube may fall into the duodenum. When it is in the second or third portion of the duodenum, 10 to 20 cc. of air is injected

8. (*a*) Harris, F. I.: Intestinal Intubation in Bowel Obstruction: Technic with a New Single Lumen Mercury Weighted Tube, Surg., Gynec. & Obst. **81:** 671-678 (Dec.) 1945. (*b*) Abbott, W. O.: Indications for the Use of the Miller-Abbott Tube, New England J. Med. **225:**641-646 (Oct. 23) 1941. (*c*) Johnston.[1] (*d*) Miller and Abbott.[4]

into the balloon. With this bulk the tube frequently passes forward rapidly with peristaltic rushes. Once in the jejunum, another 20 cc. of air is added. The tube is then allowed to pass as rapidly as peristalsis permits. It should be emphasized that constant suction is essential to forward progress of the tube, for only as the walls contact the balloon can peristalsis act on it (fig. 3). Recently we have been using a suction pump[9] which removes intestinal contents more constantly than the Wangensteen suction.

Once progress of the tube is halted, roentgenograms are taken to make certain that the bowel is completely decompressed. After decompression and restoration of the patient to a more normal physiologic status, the point of obstruction may be localized by means of a small amount of barium injected through the tube.[10]

The procedure as described may have to be varied in the case of critically ill patients. In these patients the tube may be inserted in the admitting room and the patient placed right side down and taken for roentgen examination. The usual diagnostic flat plates will also reveal position of the tube. If its direction is satisfactory, suction is attached and 2 inches (5 cm.) of slack is given every thirty minutes. If the tube is found to be directed toward the cardia, it is pulled back and the patient is again turned on his right side. Roentgenograms are taken at six hour intervals, and as soon as the balloon is in the second or third portion of the duodenum, air is inserted as mentioned before.

From 1938 to 1945 air alone was used in the balloon with the double-lumened tube. Although a high percentage of tubes were successfully passed by this technic,[11] it was frequently necessary to spend long periods in the fluoroscopic room with an extremely sick patient. Not only was this difficult for the patient but it also involved considerable exposure to radiation for both patient and surgeon. Much manipulation was necessary and frequently a wire stylet was required to direct the tube into the duodenum.[8b] We believe that the addition of mercury to the balloon is a distinct advance. We have also learned that there is considerable advantage in having the balloon beyond the tip of the tube, since this allows a wider range of motion for the mercury than does a

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9. Crowley, R. T., and Johnston, C. G.: Physiological Principles in Intestinal Obstruction, S. Clin. North America **26**:1427-1439 (Dec.) 1946.

10. Lofstrom, J. E., and Noer, R. J.: The Use of Intestinal Intubation in the Localization of Lesions of the Gastro-intestinal Tract, Am. J. Roentgenol. **42**: 321-329 (Sept.) 1939; The Role of Intestinal Intubation in the Diagnosis and Localization of Intestinal Obsrtuction, Radiology **35**:546-556 (Nov.) 1940. Golden, R.; Leigh, O. C., and Swenson, P. C.: Roentgen-Ray Examination with the Miller-Abbott Tube, ibid. **35**:521-533 (Nov.) 1940.

11. Johnston, C. G.: Decompression in the Treatment of Intestinal Obstruction, Surg., Gynec. & Obst. **70**:365-369 (Feb. 15) 1940.

proximally placed balloon. The fact that the inflated balloon passed rapidly without a suction tip proximal to it indicates that there is some passage of intestinal contents between the bowel wall and the balloon.

The new plastic tube has been used in treating 50 patients with intestinal obstruction. The average time for passage from the nose into the middle or lower part of the ileum was twenty-four hours. This time is usually shortened in the more severe cases, but the average remains at twenty-four hours because many show so much improvement after gastric and duodenal suction that efforts are not extended to advance the tube rapidly. This tube has been more satisfactory than any other which we have used so far as ease of introduction and effectiveness and rapidity of decompression are concerned. To date there has been no instance of ulceration of the mucosa even though the tube was in place for thirty-five days on one occasion and twenty-three days on another.

Three case reports are cited as typical.

CASE 1.—J. P., a Negro aged 68, entered the hospital with a diagnosis of peritonitis of unknown cause. Roentgenograms made with the patient in supine and erect positions revealed severe ileus. The double-lumened plastic tube was inserted as soon as he arrived on the ward. He was given a fluoroscopic examination two hours later, and the balloon was seen in the third portion of the duodenum. It was inflated with 20 cc. of air and advanced beyond the ligament of Treitz in but a moment. Another 20 cc. of air was injected into the balloon, and a roentgenogram made four hours later revealed the tube to be at the ileocecal junction. Subsequent operation revealed a ruptured gallbladder with a walled-off abscess. The postoperative course was excellent.

CASE 2.—J. L., a white woman aged 37, was admitted one month after a pelvic operation at another hospital. The pulse and blood pressure were unobtainable. Blood and plasma were administered immediately, and the double-lumened plastic tube was passed. Though there were some indications for immediate exploration, her general condition would not permit the procedure. Response to fluids and decompression was so remarkable after eight hours that immediate operation no longer appeared necessary. After restoration of a more normal fluid and electrolyte balance, localization was carried out through the tube. One week after her admission, operation through a small right transverse incision was carried out, and a band adhesion found at the previously localized site was severed. Her recovery was uneventful.

CASE 3.—M. B., a Negro woman aged 52, entered the hospital with acute distention and with a history of chronic intestinal obstruction. The blood urea was 280 mg., and the serum chlorides 300 mg. per hundred cubic centimeters. The double-lumened plastic tube was passed in the ward, and a roentgenogram made twelve hours later revealed the tube to be in the jejunum. The balloon was then inflated and passed rapidly down the small bowel. With decompression accomplished and the fluids and electrolytes balanced, the site of obstruction was explored through a low mid-transverse incision eleven days after admission. Chronic obstruction of the small bowel was found low in the pelvis, which was due to inflammatory adhesions about an old pyosalpinx. It was necessary to resect a segment of ileum. Recovery was complicated by an infection of the wound, from which she recovered satisfactorily. The tube was well tolerated in this patient for a period of thirty-five days.

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These cases are typical of the majority in which intestinal intubation is used. The tube is occasionally passed preoperatively in elective cases such as cases of large incisional hernias and of involvement of the colon, in which the procedure functions as an ileostomy. It is used prophylactically in many cases of gunshot wounds, strangulated hernias, peritonitis and traumatic ileus. We have found it to be an all-important adjunct not only in maintaining decompression but in allowing an early oral intake after the tip has passed the jejunum.

We are cognizant of the fact that the long tube has not had the general use it deserves, in large part because of the many difficulties encountered in its passage into the intestine. The use of mercury combined with an inflatable balloon obviates much of this difficulty. Use of this combination of a double-lumened tube with a large lumen for suction and a balloon containing both mercury and air should make possible successful intestinal intubation in all cases in which decompression is indicated even in the hands of those not accustomed to its use.

SUMMARY

A double-lumened plastic tube with an inflatable balloon containing mercury has been presented as a solution to many of the difficulties previously encountered in the procedure of intestinal intubation.

Experience in the use of this tube in 50 cases of acute intestinal obstruction has demonstrated its efficiency, ease of introduction and freedom from untoward complications.

Dr. Charles G. Johnston and Dr. Rudolf J. Noer rendered helpful criticism during the development of this tube.